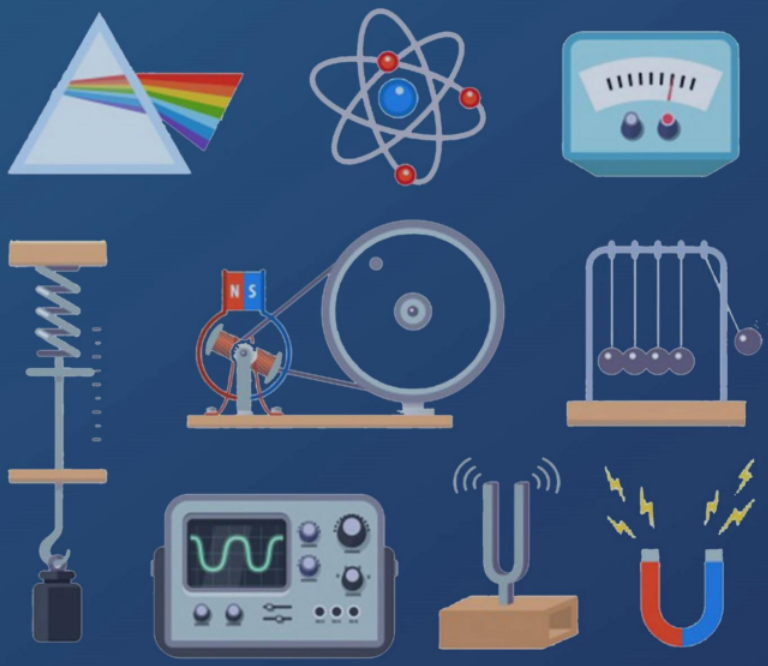
PHYSICS

Alternating Current



SHEET

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Note

Detailed solutions are available on the eSaral App.

Module Description

For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Alternating Current-Introduction				
2	Average Value and RMS Value	1	1	1	1,2
3	AC Voltage Applied to a Resistor	2			
4	AC Voltage Applied to a Capacitor	3	10	2	3
5	AC Voltage Applied to an Inductor	4	2		
6	Phasors and Phasor Diagram	5	3		
7	Impedance		11	3	4,5
8	AC Voltage Applied to Series LR circuit	6	4,12	4,5	6
9	AC Voltage Applied to Series RC circuit		9	6	
10	AC Voltage Applied to Series LCR circuit	7	5	7	7,10-12
11	Power in AC circuits-The Power Factor	8,9	13	8,9	8
12	Resonance Condition	10,11	14,15	10,11	
13	LC Oscillations	12		12	14
14	Transformers	13,14	6	13	15
15	After complete chapter	15,16	7,8	14	9,13

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Average Value and RMS Value

Q1. The r.m.s. value of alternating current is 10 ampere having frequency of 50 Hz. The time taken by the current to increase from zero to maximum and the maximum value of current will be :-

(A) 2×10^{-2} s and 14.14 A

(B) 1×10^{-2} s and 7.07 A

(C) 5×10^{-3} s and 7.07 A

(D) 5×10^{-3} s and 14.14 A

AC Voltage Applied to a Resistor

Q2. In a resistance of 25 Ω A.C. is passed to produce heat at the rate of 250 watt. The value of current in the resistance will be :–

(A) 0.316 A (B) 1 A

(C) 3.16 A (D) 10 A

AC Voltage Applied to a Capacitor

Q3. Let f = 50 Hz, and C = 100 μF in an AC circuit containing a capacitor only. If the peak value of current in the circuit is 1.57 A at t = 0, then equation for AC Voltage will be :

(A) E = 50 sin (100πt - π/2)

(B) E = 100 sin (50πt)

(C) E = 50 sin 100πt

(D) E = 50 sin (100πt + π/2)

AC Voltage Applied to an Inductor

Q4. An a.c. source of voltage V and of frequency 50Hz is connected to an inductor of 2H and negligible resistance. A current of r.m.s. value I flows in the coil. When the frequency of the voltage is changed to 400 Hz keeping the magnitude of V same, the current is now

(A) 8I in phase with V

(B) 4I and leading by 90 from V

(C) I/4 and lagging by 90^0 from V

(D) I/8 and lagging by 90^0 from V

Phasors and Phasor Diagram

Q5. A capacitor of capacitance 100 μF and a resistance of 100Ω is connected in series with AC supply of 220V, 50Hz. The current leads the voltage by :-

(A) $\tan^{-1}\left(\frac{1}{2\pi}\right)$ (B) $\tan^{-1}\left(\frac{1}{\pi}\right)$

(C) $\tan^{-1}\left(\frac{2}{\pi}\right)$ (D) $\tan^{-1}\left(\frac{4}{\pi}\right)$

AC Voltage Applied to Series LR circuit

Q6. In an A.C. circuit resistance and inductance are connected in series. The potential and current in inductance is :-

(A) $V_0 \sin \omega t, \frac{V_0}{L\omega} \sin \omega t$

(B) $V_0 \sin \omega t, \frac{V_0}{L\omega} \sin\left[\omega t + \frac{\pi}{2}\right]$

(C) $V_0 \sin\left[\omega t + \frac{\pi}{2}\right], \frac{V_0}{L\omega} \sin \omega t$

(D) $V_0 \sin\left[\omega t + \frac{\pi}{2}\right], \frac{V_0}{L\omega} \sin\left[\omega t - \frac{\pi}{2}\right]$

AC Voltage Applied to Series LCR circuit

Q7. A circuit contains R, L and C connected in series with an A. C. source. The values of the reactances for inductor and capacitor are 200Ω and 600Ω respectively and the impedance of the circuit is Z_1. What happens to the impedance of the same circuit if the values of the reactances are interchanged :-

(A) The impedance will remain unchanged

(B) The impedance will increase

(C) The impedance will decrease

(D) Information insufficient

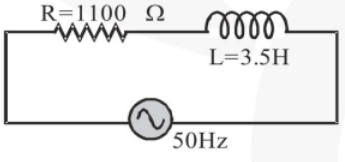
Power In AC Circuits-The Power Factor

Q8. An AC circuit draws 5A at 160 V and the power consumption is 600 W. Then the power factor is :-

(A) 1 (B) 0.75

(C) 0.50 (D) Zero

Q9. For given circuit the power factor is :-



(A) 0 (B) $\frac{1}{2}$

(C) $\frac{1}{\sqrt{2}}$ (D) none of these

Resonance Condition

Q10. An inductance of $1mH$, a condenser of $10\mu F$ and a resistance of 50Ω are connected in series. The reactance of inductor and condensers are same. The reactance of either of them will be :-

(A) 100 Ω (B) 30 Ω

(C) 3.2 Ω (D) 10 Ω

Q11. In LCR circuit, capacitor C is changed to 4C, then what should be the value of L to keep resonance frequency same :-

(A) 2L (B) $\frac{L}{2}$ (C) $\frac{L}{4}$ (D) 4L

LC Oscillations

Q12. Which statement is correct from following-

(a) Inductor store energy in the form of magnetic field

(b) Capacitor store energy in the form of electric field

(c) Inductor store energy in the form of electric and magnetic field both

(d) Capacitor store energy in the form of electric and magnetic field both

(A) a, b (B) a, c

(C) b, d (D) b, c

Transformers

Q13. The number of turns in the primary and secondary of transformer are N_P and N_S respectively. The resistance of the secondary circuit is R_S. Then equivalant resistance of primary circuit :–

(A) $R_s\frac{N_S}{N_P}$ (B) $R_s\left[\frac{N_S}{N_P}\right]^2$

(C) $R_s\frac{N_P}{N_S}$ (D) $R_s\left[\frac{N_P}{N_S}\right]^2$

Q14. The ratio of the secondary to the primary turns in a transformer is 3 : 2 and the output power is P. Neglecting all power losses, the input power must be :-

(A) $\frac{P}{2}$ (B) P

(C) $\frac{2P}{3}$ (D) $\frac{3P}{2}$

After Complete Chapter

Q15. The dimensions of combination $\frac{L}{CVR}$ are same as dimensions of :-

(A) Change (B) Current

(C) Charge^{-1} (D) Current^{-1}

Q16. L, C and R respectively indicate inductance, capacitance and resistance. Select the combination, which does not have dimensions of frequency :-

(A) 1/RC (B) R/L

(C) $1/\sqrt{LC}$ (D) C/L

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A generator produces a voltage V=240 sin120t volt where V is in volts and t in second. The frequency and r.m.s. voltage are nearly :-

(A) 60 Hz and 240 V

(B) 19 Hz and 120 V

(C) 19 Hz and 170 V

(D) 754 Hz and 170 V

Q2. In a circuit the frequency is $f = \frac{1000}{2\pi}$ Hz and the inductance is 2 henry, then the reactance will be :-

(A) 200 Ω (B) 200 μΩ

(C) 2000 Ω (D) 2000 μΩ

Q3. 200 Ω resistance and 1H inductance are connected in series with an A.C. circuit. The frequency of the source is $\frac{200}{2\pi}$ Hz. Then phase difference in between V and I will be :-

(A) 30° (B) 60°

(C) 45° (D) 90°

Q4. An LR circuit with a battery is connected at t = 0. Which of the following quantities is not zero just after the circuit.

(A) current in the circuit

(B) magnetic field energy in the inductor

(C) power delivered by the battery

(D) emf induced in the inductor

Q5. For a LCR series circuit with an A.C. source of angular frequency ω :

(A) circuit will be capacitive if $\omega > \frac{1}{\sqrt{LC}}$

(B) circuit will be inductive if $\omega > \frac{1}{\sqrt{LC}}$

(C) power factor of circuit will by unity if capacitive reactance equals inductive reactance

(D) current will be leading if $\omega > \frac{1}{\sqrt{LC}}$

Q6. The core of any transformer is laminated so as to -

(A) Make it light weight

(B) Make it robust and strong

(C) Increase the secondary voltage

(D) Reduce the energy loss due to eddy current

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 7 & 8

In an L - C - R series circuit connected to an AC source, $V = V_0 \sin 5\left(100\pi t + \frac{\pi}{6}\right)$.

Given V_R = 40 V, V_L = 40 V and V_C = 10 V. Resistance R = 4Ω.

Q7. Peak value of current in the circuit is :-

(A) $10\sqrt{2}$ A (B) $15\sqrt{2}$ A

(C) $20\sqrt{2}$ A (D) $25\sqrt{2}$ A

Q8. Choose the correct option :-

(A) $L = \frac{1}{25\pi}$ H

(B) $C = \frac{1}{50\pi}$ F

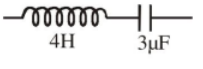
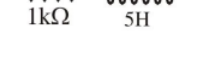
(C) both (A) and (B) are correct

(D) both (A) and (B) are wrong

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q9. Match the following items –

Column-I **Circuit component across an ac source (ω = 200 rad/sec)**	**Column-II** **Phase difference between current and source voltage**
(A)	(P) $\frac{\pi}{2}$
(B)	(Q) $\frac{\pi}{6}$
(C)	(R) $\frac{\pi}{4}$
(D) 	(S) $\frac{\pi}{3}$
(E) 	(T) None of the above

SUBJECTIVE TYPE

Q10. A 15.0 μF capacitor is connected to a 220 V, 50 Hz source. Find the capacitive reactance and the current (rms and peak) in the circuit. If the frequency is doubled, what happens to the capacitive rectance and the current ?

Q11. A bulb is connected to a mains line of 200 V, 50 Hz. If the bulb draws the same current of 10A from a dc source of 100 V, then find the inductance of the filament of the bulb.

Q12. A coil of reactance 100 Ω and resistance 100 Ω is connected to a 240 V, 50 Hz a.c. supply.

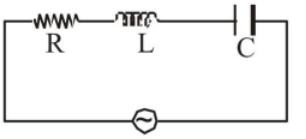
(a) What is the maximum current in the coil?

(b) What is the time lag between the voltage maximum and the current maximum ?

Q13. In given circuit R = 100Ω. If voltage leads current by 60° then find -

(a) Maximum Current supply by source.

(b) Average power

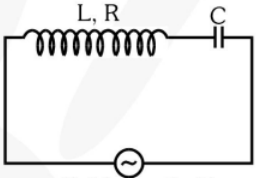


$V = 200\sin 100\pi t$ volt

Q14. A coil, a capacitor and an a.c. source of rms voltage 24V are connected in series, by varying the frequency of the source, a maximum rms current 6A is observed, if this coil is connected to a battery of emf 12V and internal resistance 4Ω, then calculate the current through the coil.

Q15. A coil of resistance R and inductance L is connected in series with a capacitor C and complete combination is connected to a a.c. voltage, Circuit resonates when angular frequency of supply is $\omega = \omega_0$.

Find out relation betwen ω_0, L and C.



Exercise - 2 — *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. The current in a discharging LR circuit is given by $i = i_0 e^{-t/\tau}$ where τ is the time constant of the circuit. Calculate the rms current for the period $t = 0$ to $t = \tau$.

(A) $\frac{i_0}{e}\sqrt{\frac{(e^2-1)}{2}}$ (B) $\frac{i_0}{e}\sqrt{\frac{(e^{-2}+1)}{2}}$

(C) $\frac{i_0}{e}\sqrt{\frac{(e+2)}{3}}$ (D) $\frac{i_0}{e}\sqrt{\frac{(e^2-2)}{2}}$

Q2. In an A.C. circuit capacitance of 5μF has a reactance 1000 Ω. The frequency of A.C. will be :–

(A) $\frac{1000}{\pi}$ cycle/s (B) $\frac{100}{\pi}$ cycle/s

(C) 200 cycle/s (D) 5000 cycle/s

Q3. When 100V D.C. is applied across a coil a current of 1A flows through it. When 100V A.C. of 50 Hz is applied to the same coil only 0.5A flows. The inductance of the coil is :–

(A) 0.55 H

(B) 55 mH

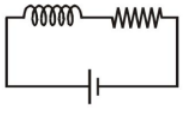
(C) 0.55 mH

(D) 5.5 mH

Q4. A 12 ohm resistor and a 0.21 henry inductor are connected in series to an AC source operating at 20 volts, 50 cycle/second. The phase angle between the current and the source voltage is:

(A) 30° (B) 40° (C) 80° (D) 90°

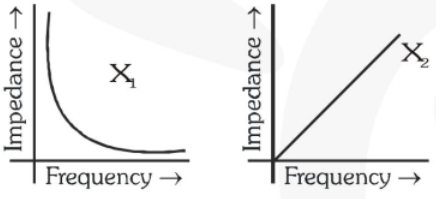
Q5. Time constant of the given circuit is τ. If the battery is replaced by an AC source having voltage $V = V_0 \cos \omega t$, power factor of the circuit will be :-



(A) $\omega\tau$ (B) $\frac{1}{\sqrt{1+(\omega\tau)^2}}$

(C) $\sqrt{1+(\omega\tau)^2}$ (D) None

Q6. The graphs given below depict the dependence of two reactive impedances X_1 and X_2 on the frequency of the alternating e.m.f. applied individually to them. We can then say that :



(A) X_1 is an inductor and X_2 is a capacitor
(B) X_1 is a resistor and X_2 is a capacitor
(C) X_1 is a capacitor and X_2 is an inductor
(D) X_1 is an inductor and X_2 is a resistor

Q7. Which of the following statements is correct, for an LCR series combination having the resonating condition as :-

(A) the current is minimum.

(B) the phase difference between the current and e.m.f. is $\frac{\pi}{2}$.

(C) the impedance is equal to R.

(D) the value of power factor is minimum.

Q8. Power factor of an L–R series circuit is 0.6 and that of a C–R series circuit is 0.5. If the element (L,C, and R) of the two circuits are joined in series the power factor of this circuit is found to be 1. The ratio of the resistance in the L–R circuit to the resistance in the C–R circuit is -

(A) $\frac{6}{5}$ (B) $\frac{5}{6}$ (C) $\frac{4}{3\sqrt{3}}$ (D) $\frac{3\sqrt{3}}{4}$

Q9. A series R - L - C ($R = 10\ \Omega$, $X_L = 20\ \Omega$, $X_C = 20\ \Omega$) circuit is supplied by $V = 10 \sin \omega t$ volt then power dissipation in circuit is :-

(A) Zero (B) 10 watt
(C) 5 watt (D) 2.5 watt

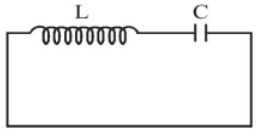
Q10. The self inductance of the motor of an electric fan is 10 H. In order to impart maximum power at 50Hz. It should be connected to a capacitance of :

(A) 2×10^{-6} F (B) 3×10^{-6} F
(C) 10^{-4} F (D) 10^{-6} F

Q11. In a series resonant R-L-C circuit, if L is increased by 25% and C is decreased by 20%, then the resonant frequency will :

(A) Increases by 10%
(B) Decreases by 10%
(C) Remain unchanged
(D) Increases by 2.5%

Q12. In an LC circuit, the capacitor has maximum charge q_0. The value of $\left|\frac{di}{dt}\right|_{max}$ is -



(A) $\frac{q_0}{LC}$ (B) $\frac{q_0}{\sqrt{LC}}$

(C) $\frac{q_0}{LC} - 1$ (D) None of these

Q13. An ideal efficient transformer has a primary power input of 10kW. The secondary current when the transformer is on load is 25A. If the primary : secondary turns ratio is 8 : 1, then the potential difference applied to the primary coil is

(A) $\frac{10^4 \times 8^2}{25}$ V (B) $\frac{10^4 \times 8}{25}$ V

(C) $\frac{10^4}{25 \times 8}$ V (D) $\frac{10^4}{25 \times 8^2}$ V

Q14. An AC voltage source of variable angular frequency ω and fixed amplitude V connected in series with a capacitance C and an electric bulb of resistance R (inductance zero). When ω is increased :

(A) the bulb glows dimmer

(B) the bulb glows brighter

(C) total impedence of the circuit is unchanged

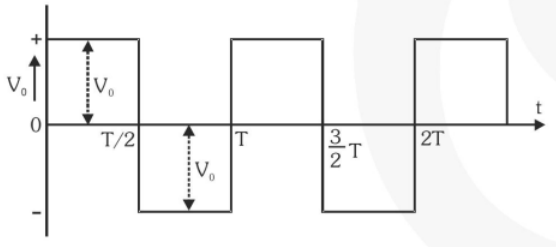
(D) total impedence of the circuit increases

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The average and rms value of voltage for square wave shown in fig. having peak value V_0 -



(A) $\frac{V_0}{\sqrt{2}}$, $\sqrt{2}V_0$ (B) $\sqrt{2}V_0$, $\frac{V_0}{\sqrt{2}}$

(C) V_0, V_0 (D) Zero, Zero

Q2. A current in circuit is given by $i = 3 + 4 \sin \omega t$. Then the effective value of current is :

(A) 5 (B) $\sqrt{7}$

(C) $\sqrt{17}$ (D) $\sqrt{10}$

Q3. A capacitor of capacity C is connected in A.C. circuit. The applied emf is $V=V_0 \sin\omega t$, then the current is -

(A) $I = \frac{V_0}{C\omega} \sin\omega t$

(B) $I = \frac{V_0}{C\omega} \sin\left[\omega t + \frac{\pi}{2}\right]$

(C) $I = V_0 C\omega \sin\omega t$

(D) $I = V_0 C\omega \sin\left[\omega t + \frac{\pi}{2}\right]$

Q4. A student connects a long air cored - coil of manganin wire to a 100 V D.C. supply and records a current of 25 amp. When the same coil is connected across 100 V, 50 Hz AC. the current reduces to 20 A , the reactance of the coil is :-

(A) 4 Ω (B) 3 Ω

(C) 5 Ω (D) None

Q5. A capacitor has a resistance of 12 ohm and a capacitance of 22 microfarad. It is connected to an AC supply of 80 Hz, then the e.m.f. of the AC supply required to drive a current of 10 virtual ampere is -

(A) $904\sqrt{2}$ volt (B) 913 volt

(C) $\frac{904}{\sqrt{2}}$ volt (D) 452 volt

Q6. For L-R circuit, the time constant is equal to -

(A) twice the ratio of the energy stored in the magnetic field to the rate of the dissipation of energy in the resistance.

(B) the ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance

(C) half of the ratio of the energy stored in the magnetic field to the rate of dissipation of energy in the resistance

(D) square of the ratio of the energy stored in the magnetic field to the rate of dissipation energy in the resistance

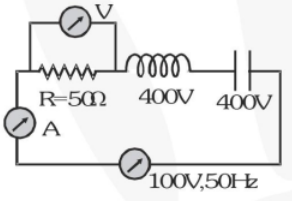
Q7. In given LCR circuit, the voltage across the terminals of a resistance and current will be:-

(A) 400V, 2A

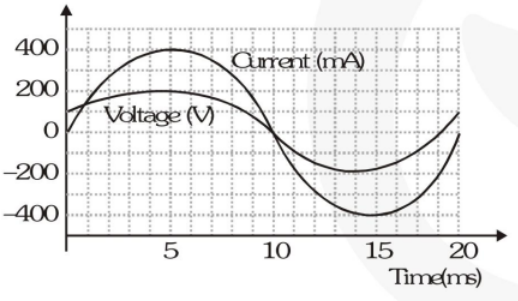
(B) 800V, 2A

(C) 100V, 2A

(D) 100V, 4A



Q8. The given graph shows variation with time in the source voltage and steady state current drawn by a series RLC circuit :-



Which of the following statements is/are correct?

(a) Current lags the voltage

(b) Resistance in the circuit is $250\sqrt{3}\Omega$

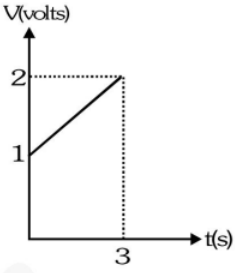
(c) Reactance in the circuit is 250Ω

(d) Average power dissipation in the circuit is $20\sqrt{3}$W

(A) Only a (B) a & b

(C) a, b & c (D) All

Q9. A circuit element is placed in a closed box. At time t = 0, constant current generator supplying a current of 1 A, is connected across the box. Potential difference across the box varies according to graph shown in figure. The element in the box is/are :



(A) resistance of 2Ω

(B) battery of emf 6V

(C) inductance of 2H

(D) capacitance of 0.5 F

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for question nos. 10 to 12

If various elements, i.e., resistance, capcitance and inductance which are in series and having values 1000 Ω, 1μF and 2.0 H respectively. Given emf as, $V = 100\sqrt{2}\sin 1000\,t$ volts.

Q10. Voltage across the resistor is -

(A) 70.7 Volts (B) 100 Volts

(C) 141.4 Volts (D) 270.7 Volts

Q11. Voltage across the inductor is -

(A) 70.7 Volts (B) 100 Volts

(C) 141.4 Volts (D) 270.7 Volts

Q12. Voltage across the capacitor is

(A) 70.7 Volts (B) 100 volts

(C) 141.4 Volts (D) 270.7 Volts

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q13. Instantaneous voltage and instantaneous current in an L-R AC circuit is V = 100 sin (100 t) and $i = 10 \sin\left(100t - \frac{\pi}{4}\right)$. Match the entries of column I with the entries of column II.

Column-I	**Column-II**
(a) R	(p) $(1/10\sqrt{2})$SI unit
(b) X_L	(q) $5\sqrt{2}$ SI unit
(c) L	(r) $10\sqrt{2}$ SI unit
(d) Average power in one cycle	(s) None of these

(A) (a - p), (b - q), (c - r), (d -s)
(B) (a - q), (b - p), (c - s), (d - s)
(C) (a - q), (b - q), (c - p), (d -s)
(D) None of these

SUBJECTIVE TYPE

Q14. Comparing the L–C oscillations with the oscillations of a spring–block system (force constant of spring = k and mass of block = m), the physical quantity mk is similar to _____.

Q15. A transformer having efficiency 90% is working on 100 V and at 2.0 kW power. If the current in the secondary coil is 5A, calculate (i) the current in the primary coil and (ii) voltage across the secondary coil.

Answer Key

Ex-1									
1	2	3	4	5	6	7	8	9	10
D	C	C	D	B	C	A	B	C	D
11	12	13	14	15	16				
C	A	D	B	D	C				

Ex-1A

1. C **2.** C **3.** C **4.** D **5.** B,C

6. D **7.** A **8.** A

9. (A) → (R) ; (B) → (P) ; (C) → (P) ; (D) → (T) ; (E) → (R)

10. 1/2 , 2 **11.** 0.055H **12.** (a) 2.4 A (b) 2.5 ms.

13. (a) 1 A (b) 50Watt **14.** 1.5 A **15.** $\omega_0 = \frac{1}{\sqrt{LC}}$

Ex-2									
1	2	3	4	5	6	7	8	9	10
A	B	A	C	B	C	C	C	C	D
11	12	13	14						
C	A	B	B						

Ex-2A

1. C **2.** C **3.** D **4.** B **5.** B

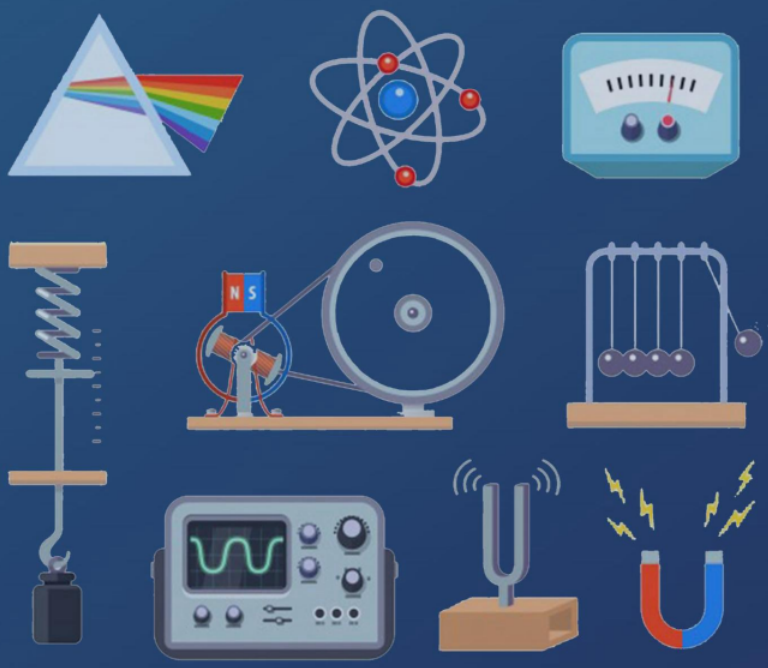
6. A **7.** C **8.** D **9.** D **10.** A

11. C **12.** A **13.** C **14.** $\frac{L}{C}$

15. (i) 20 A (ii) 360 V

PHYSICS

Atomic Structure



SHEET

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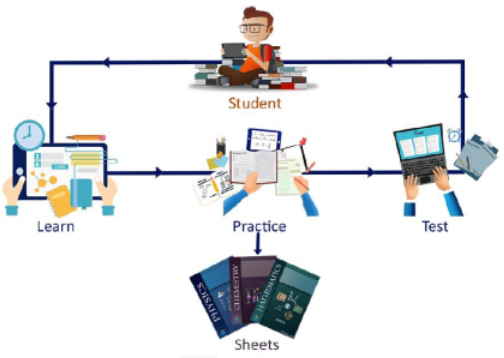
7.	Answer Key	Page - 10

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Discovery of electron and its charge	1			
2	Rutherford model and the discovery of proton,nucleus and neutron		1		
3	Size of nucleus and drawbacks of Rutherford model	2,3			
4	Wave Basics	4			
5	EM waves and Planck's theory	5	2		
6	Bohr's model	6-9	3,4,7,11-13	1-6	1-9,19
7	Spectrum and Rydberg's formula	10-14	5,14	7-10	10-14, 21,23
8	Drawback of Bohr, light: wave or particle?	15			
9	De broglie explanation of bohr's second postulate of Quantisation	16,17		11	
10	After Full Chapter		6,8,9,10		15-18, 20, 22

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Discovery of electron and its charge

Q1. Charge on electron is -
(A) -1.6×10^{-19}C (B) -1.6×10^{-10}C
(C) -4.8×10^{-10}C (D) Zero

Size of nucleus and drawbacks of Rutherford model

Q2. The size of an atom is of the order of :
(A) 10^{-8} cm (B) 10^{-10} cm
(C) 10^{-12} cm (D) 10^{-6} cm

Q3. An atom having atomic mass number 13 has 7 neutrons. What is the atomic number of the atom ?
(A) 6 (B) 7
(C) 8 (D) 9

Wave Basics

Q4. Calculate the wave number of a radiation having wavelength 600 nm ?
(A) 1.67×10^{8} m^{-1} (B) 1.67×10^{10} m^{-1}
(C) 1.67×10^{12} m^{-1} (D) 1.67×10^{6} m^{-1}

EM waves and Planck's theory

Q5. The frequency of an electromagnetic radiation is 2×10^{6} Hz. What is its wavelength in metres
(Velocity of light = 3×10^{8} ms^{-1})
(A) 6.0×10^{14} (B) 1.5×10^{4}
(C) 1.5×10^{2} (D) 6.0×10^{-2}

Bohr's model

Q6. The energy required to remove an electron in a hydrogen atom from n = 10 state is-
(A) 13.6 eV (B) 1.36 eV
(C) 0.136 eV (D) 0.0136 eV

Q7. The binding energy of an electron with n = 4 in the H-atom is-
(A) 13.6 eV (B) 3.4 eV
(C) 1.51 eV (D) 0.85 eV

Q8. The velocity of electron in the first Bohr orbit of He^{+} ions is-
(A) c (B) c/137
(C) 2c/137 (D) 4c/137

Q9. The ratio of energies of first two excited states hydrogen atom is -
(A) 3/1 (B) 1/4
(C) 4/9 (D) 9/4

Spectrum and Rydberg's formula

Q10. The number of different wavelengths may be observed in the spectrum from a hydrogen sample if the atoms are excited to third excited state is -
(A) 3 (B) 4
(C) 5 (D) 6

Q11. The transition from the state n = 4 to n = 3 in a hydrogen like atom results in ultraviolet radiation. Infrared radiation will be obtained in the transition :
(A) $2 \rightarrow 1$ (B) $3 \rightarrow 2$
(C) $4 \rightarrow 2$ (D) $5 \rightarrow 4$

Q12. The shortest wavelength present in the Brackett series of a spectral line is-
(A) 912Å (B) 8201Å
(C) 1.46 μm (D) 2.28 μm

Q13. Out of following spectral series of hydrogen spectrum, the one which lies wholly in the ultraviolet region is-
(A) Balmer series
(B) Brackett series
(C) Paschen series
(D) Lyman series

Q14. The wave number of the series limit of Lyman series is-

(A) $1.097 \times 10^7\ m^{-1}$

(B) $2.74 \times 10^6\ m^{-1}$

(C) $1.22 \times 10^6\ m^{-1}$

(D) $6.86 \times 10^5\ m^{-1}$

Drawback of Bohr, light : wave or particle?

Q15. According to the modern theory for nature of light, the light has-

(A) wave nature only

(B) particle nature only

(C) dual nature

(D) none of these

De broglie Explanation of Bohr's second postulate of quantisation

Q16. According to De Broglie, wavelength of electron in second orbit is 10^{-9} metre. Then the circumfrance of orbit is-

(A) 10^{-9} m (B) 2×10^{-9} m

(C) 3×10^{-9} m (D) 4×10^{-9} m

Q17. When a hydrogen atom emits a photon of energy 12.1 eV,its orbital angular momentum changes by :

(A) $1.05\times10^{-34}\ J-s$

(B) $2.11\times10^{-34}\ J-s$

(C) $3.16\times10^{-34}\ J-s$

(D) $4.22\times10^{-34}\ J-s$

Exercise - 1A Concept Builder

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Rutherford's experiment established that :

(A) Inside the atom there is a heavy positive centre

(B) Nucleus contains protons and neutrons

(C) Most of the space in the atoms is empty

(D) Size of the nucleus is very small

Q2. The energies E_1 and E_2 of two radiations are 25 eV and 50eV respectively. The relation between their wavelengths i.e. λ_1 and λ_2 will be?

(A) $\lambda_1 = \lambda_2$ (B) $\lambda_1 = 2\lambda_2$

(C) $\lambda_1 = 4\lambda_2$ (D) $\lambda_1 = \frac{1}{2}\lambda_2$

Q3. For a doubly ionised Li–atom

(A) Angular momentum of an electron in 3rd orbit is $\frac{3h}{2\pi}$

(B) Energy of electron in 2nd excited state is –13.6 eV

(C) Speed of electron in 3rd orbit is $\frac{c}{137}$, where c is speed of light

(D) Kinetic energy of electron is 2nd excited state is half of the magnitude of the potential energy

Q4. A particular hydrogen like atom has its ground state binding energy 122. 4 eV. It is in ground state. Then -

(A) Its atomic number is 3.

(B) An electron of 90 eV can excite it.

(C) An electron of kinetic energy nearly 91.8 eV can be brought to almost rest by this atom.

(D) An electron of kinetic energy 2.6 eV may emerge from the atom when electron of kinetic energy 125 eV collides with this atom.

Q5. An electron in hydrogen atom after absorbing energy photons can jump between energy states n_1 and n_2 ($n_2 > n_1$). Then it may return to ground state after emitting six difference wavelengths in emission spectrum. The energy of emitted photons is either equal to, less than or greater than the absorbed photons. Then n_1 and n_2 are :-

(A) $n_2 = 4, n_1 = 3$

(B) $n_2 = 5, n_1 = 3$

(C) $n_2 = 4, n_1 = 2$

(D) $n_2 = 5, n_1 = 1$

Q6. A beam of ultraviolet light of all wavelengths passes through hydrogen gas at room temperature, in the x–direction. Assume that all photons emitted due to electron transition inside the gas emerge in the y–direction. Let A and B denote the lights emerging from the gas in the x and y directions respectively.

(A) Some of the incident wavelengths will be absent in A.

(B) Only those wavelengths will be present in B which are absent in A.

(C) B will contain some visible light.

(D) B will contain some infrared light.

Q7. The magnitude of angular momentum, orbit radius and frequency of revolution of electron in hydrogen atom corresponding to quantum number n are L, r and f respectively. Then according to Bohr's theory of hydrogen atom

(A) fr^2L is constant for all orbits

(B) frL is constant for all orbits

(C) f^2rL is constant for all orbits

(D) frL^2 is constant for all orbits

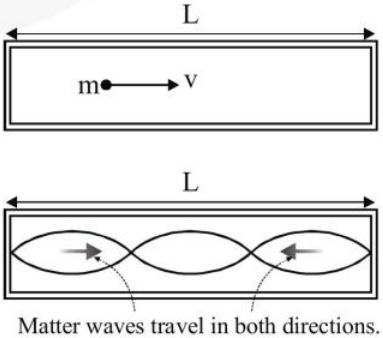
PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question. 8 to 10

While conducting his doctoral research in theoretical physics and with no experimental evidence to go on, de Broglie reasoned by analogy with Einstein's equation E = hf and with some of the ideas of his theory of relativity. The details need not concern us, but they led de Broglie to postulate that if a material particle of momentum p = mv has a wave-like nature, then its wavelength must be given by $\lambda = \frac{h}{p} = \frac{h}{mv}$ where h is Planck's constant. This is called the de-Broglie wavelength.

de-Broglie considered a matter wave to be a traveling wave. But suppose that a "particle" of matter is confined to a small region of space and cannot travel. How do the wave-like properties manifest themselves? This is the problem of "a particle in a box." Figure shows a particle of mass m moving in one dimension as it bounces back and forth with speed v between the ends of a box of length L. We'll call this a one-dimensional box; its width isn't relevant. A particle in a box creates a standing de Broglie wave as it reflects back and forth.



Matter waves travel in both directions.

Q8. What should be de-Broglie wavelength of confined particle in the box [here n∈N].

(A) $\frac{L}{2n}$ (B) $\frac{2L}{n}$ (C) $\frac{L}{n}$ (D) nL

Q9. Confined particle's energy is given by :

(A) $\frac{n^2h^2}{2mL^2}$ (B) $\frac{2n^2h^2}{mL^2}$

(C) $\frac{n^2h^2}{8mL^2}$ (D) $\frac{n^2h^2}{4mL^2}$

Q10. Consider an oil drop from Millikan's oil drop experiment having diameter 1 μm confined between the plates separated by 10 μm. Density of oil is 900 kg/m^3. What is minimum energy of such an oil drop?

[Given : h = 6.63 × 10^{-34} Js]

(A) 2.4 × 10^{-42} J

(B) 1.2 × 10^{-42} J

(C) 3.6 × 10^{-42} J

(D) 4.8 × 10^{-42} J

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q11. In each situation of column–I a physical quantity related to orbiting electron in a hydrogen like atom is given. The terms 'Z' and 'n' given in column–II have usual meaning in Bohr's theory. Match the quantities in column–I with the terms they depend on in column–II :-

	Column-I		**Column-II**
(A)	Frequency of orbiting electron	(P)	Is directly proportional to Z^2
(B)	Angular momentum of orbiting electron	(Q)	Is directly proportional to n
(C)	Magnetic moment of orbiting electron	(R)	Is inversely proportional to n^3
(D)	The average current due to orbiting of electron	(S)	Is independent of Z
		(T)	None of these

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q12. Find the ratio of the area of orbit of first excited state of electron to the area of orbit of ground level for hydrogen atom.

Q13. When an electron jump from second orbit to ground state of hydrogen atom then calculate the wavelength of emitted photon.

SUBJECTIVE TYPE

Q14. A stationary hydrogen atom of mass M emits a photon corresponding to the longest wavelength of Balmer series. The recoil velocity acquired by the atom is-

(R = Rydberg constant and h = plank's constant)

Exercise - 2 — Brain Booster

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. The velocity of an electron in single electron atom in an orbit.

(A) is independent of the atomic number of the element

(B) increases with increase in atomic number

(C) decreases with increase in atomic number

(D) increases with increase in quantum number

Q2. An energy of 24.6 eV is required to remove one of the electrons from a neutral helium atom. The energy (in eV) required to remove both the electrons form a neutral helium atom is -

(A) 38.2 (B) 49.2

(C) 51.8 (D) 79.0

Q3. If the atom $_{100}Fm^{257}$ follows the Bohr model and the radius of $_{100}Fm^{257}$ is n times the Bohr radius, then find n.

(A) 100 (B) 200

(C) 4 (D) 1/4

Q4. Let the potential energy of a hydrogen atom in the ground state be zero. Then its energy in the first excited state will be :

(A) 10.2eV (B) 13.6eV

(C) 23.8eV (D) 27.2eV

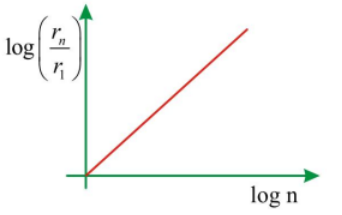
Q5. Ratio of difference of spacing between the energy levels with n = 3 and n = 4 and the spacing between the energy levels with n = 8 and n = 9 for a hydrogen like atom or ion is -

(A) 0.71 (B) 0.41

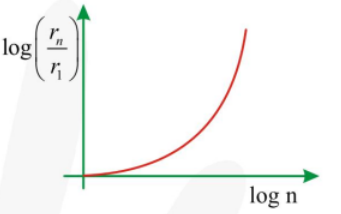
(C) 2.43 (D) 14.82

Q6. In hydrogen atom, the radius of nth Bohr orbit is r_n. The graph between $\log\left(\frac{r_n}{r_1}\right)$ and log n will be:

(A)



(B)



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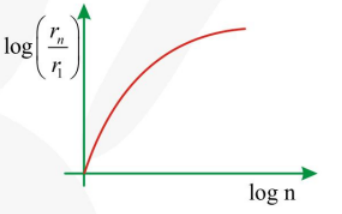
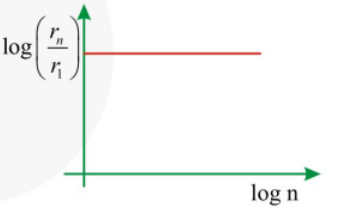


(D)



Q7. A photon collides with a stationary hydrogen atom in ground state inelastically. Energy of the colliding photon is 10.2 eV. After a time interval of the order of micro second another photon collides with same hydrogen atom inelastically with an energy of 15 eV. What will be observed by the detector?

(A) 2 photon of energy 10.2 eV.

(B) 2 photon of energy of 1.4 eV.

(C) One photon of energy 10.2 eV and an electron of energy 1.4 eV.

(D) One photon of energy 10.2 eV and another photon of energy 1.4 eV.

Q8. If $\lambda = c_2\left[\frac{n^2}{n^2-2^2}\right]$ for balmer series, what is the value of c_2 ?

(A) $\frac{4}{R_H}$ (B) $\frac{2}{R_H}$

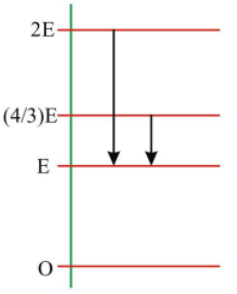
(C) $2R_H$ (D) $4R_H$

Q9. The largest wavelength in the lymen series of the hydrogen spectrum is 122 nm. The smallest wavelength in the paschen series of the hydrogen spectrum (to the nearest integer) is :

(A) 802 nm (B) 823 nm

(C) 1882 nm (D) 1648 nm

Q10. The figure shows energy levels of a certain atom, when the system moves from level 2E to E, a photon of wavelength λ is emitted. The wavelength of photon produced during its transition from level 4/3 E to E level is :



(A) 3λ (B) 3/4λ

(C) λ/4 (D) 2λ

Q11. Calculate the energy of a photon of sodium light of wavelength 2×10^{-16} m ?

(A) 9.9×10^{-10} J (B) 6.6×10^{-11} J

(C) 9.9×10^{-12} J (D) 4.8×10^{-11} J

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Let A_n be the area enclosed by the nth orbit in a hydrogen atom.

The graph of $\ln(A_n / A_1)$ against $\ln(n)$:

(A) will pass through the origin

(B) will be certain points lying on a straight line with slope 4

(C) will be a monotonically increasing nonlinear curve

(D) will be a circle

Q2. The electrons in a hydrogen atom make a transition $n_1 \rightarrow n_2$ are the principal quantum numbers of two states. Assume the Bohr's model to be valid. The time period of the electron in the initial state is eight times that in the final state. The possible values of n_1 and n_2 are :

(A) $n_1 = 4, n_2 = 2$ (B) $n_1 = 8, n_2 = 2$

(C) $n_1 = 8, n_2 = 1$ (D) $n_1 = 6, n_2 = 3$

Q3. In Bohr's model of the hydrogen atom, let R. V. T, and E represent the radius of the orbit, speed of the electron, time period of revolution of electron, and the total energy of the electron, respectively. The quantities proportional to the quantum number *n* are :

(A) VR (B) RE

(C) $\frac{T}{R}$ (D) $\frac{V}{E}$

Q4. Imagine an atom made up of proton and a hypothetical particle of double the mass of the electron but having the same charge as the electron. Apply the Bohr atom model and consider all possible transitions of this hypothetical particle to the first excited level. The longest wavelength photon that will be emitted has wavelength λ (given in terms of the Rydberg constant R for hydrogen atom) equal to :

(A) 9/5 R (B) 36/5R

(C) 18/5R (D) 4/R

Q5. A hydrogen atom and a Li^{2+} ion are both in the second excited state. If ℓ_H and ℓ_{Li} are their respective electronic angular momenta and E_H and E_{Li} their respective energies, then :

(A) $\ell_H > \ell_{Li}$ and $|E_H| > |E_{Li}|$

(B) $\ell_H = \ell_{Li}$ and $|E_H| < |E_{Li}|$

(C) $\ell_H = \ell_{Li}$ and $|E_H| > |E_{Li}|$

(D) $\ell_H < \ell_{Li}$ and $|E_H| < |E_{Li}|$

Q6. The electron in a hydrogen atom makes a transition from an excited state to the ground state. Which of the following statement is true?

(A) Its kinetic energy increases and its potential and total energy decreases

(B) Its kinetic energy decreases, potential energy increases and its total energy remains the same

(C) Its kinetic and total energy decreases and its potential energy increases

(D) Its kinetic, potential and total energy decrease

Q7. In the hydrogen atom, if the reference level of potential energy is assumed to be zero at the ground state level. Choose the incorrect statement.

(A) The total energy of the shell increases with increase in the value of n.

(B) The total energy of the shell decrease with increase in the value of n.

(C) The difference in total energy of any two shells remains the same.

(D) The total energy at the ground state becomes 13.6 eV.

Q8. When a hydrogen atom is excited from ground state to first excited state then :

(A) Its kinetic energy increases by 10.2 eV.

(B) Its kinetic energy decreases by 10.2 eV.

(C) Its potential energy increases by 20.4 eV.

(D) Its angular momentum increases by 1.05×10^{-34} J–s.

Q9. Suppose the potential energy between electron and proton at a distance r is given by $-\frac{Ke^2}{3r^3}$.

Application of Bohr's theory to hydrogen atom in this case shows that :

(A) energy in the nth orbit is proportional to n^6

(B) energy is proportional to m^{-3} (m = mass of electron)

(C) energy in the nth orbit is proportional to n^{-2}

(D) energy is proportional to m^3 (m = mass of electron)

Q10. Hydrogen atoms absorb radiation of wavelength λ_0 and consequently emit radiations of 6 different wavelengths of which two wavelengths are shorter than λ_0. Then -

(A) The final excited state of the atoms is $n = 4$

(B) The initial state of the atoms may be $n = 2$

(C) The initial state of the atoms may be $n = 3$

(D) There are three transitions belonging to Lyman series

Q11. The electron in a hydrogen atom jumps back from an excited state to ground state, by emitting a photon of wavelength $\lambda_0 = \frac{16}{15R}$, where R is Rydberg's constant. In place of emitting one photon, the electron could come back to ground state by :

(A) Emitting 3 photons of wavelengths λ_1, λ_2 and λ_3 such that $\frac{1}{\lambda_1} + \frac{1}{\lambda_2} + \frac{1}{\lambda_3} = \frac{15R}{16}$

(B) Emitting 2 photons of wavelength λ_1 and λ_2 such that $\frac{1}{\lambda_1} + \frac{1}{\lambda_2} = \frac{15R}{16}$

(C) Emitting 2 photons of wavelength λ_1 and λ_2 such that $\lambda_1 + \lambda_2 = \frac{16}{15R}$

(D) Emitting 3 photons of wavelength λ_1, λ_2 and λ_3 such that $\lambda_1+\lambda_2+\lambda_3 = \frac{16}{15R}$

Q12. In a hydrogen atom, the electron is in n^{th} excited state. It may come down to second excited state by emitting ten different wavelengths. What is the value of n ?

(A) 6 (B) 7

(C) 8 (D) 5

Q13. Monochromatic radiation of wavelength λ is incident on a hydrogen sample containing in ground state. Hydrogen atoms absorb the light and subsequently emit radiations of ten different wavelengths. The value of λ is -

(A) 95 nm (B) 103 nm

(C) 273 nm (D) 88 nm

Q14. The electron in hydrogen atom in a sample is in n^{th} excited state, then the number of different spectrum lines obtained in its emission spectrum will be :

(A) $1 + 2 + 3 + ... + (n - 1)$

(B) $1 + 2 + 3 + ... + (n)$

(C) $1 + 2 + 3 + ... + (n + 1)$

(D) $1 \times 2 \times 3 \times .....\times (n - 1)$

Q15. The electric potential between a proton and an electron is given by $V = V_0 \ell n \frac{r}{r_0}$, where r_0 is a constant. Assuming Bohr's model to be applicable, write variation of r_n with n, n being the principal quantum number :–

(A) $r_n \propto n$ (B) $r_n \propto \frac{1}{n}$

(C) $r_n \propto n^2$ (D) $r_n \propto \frac{1}{n^2}$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question Nos. 16 to 18

An electron is orbiting in a circular orbit of radius r under the influence of a constant strong magnetic field of strength B. Assuming that Bohr's postulate regarding the quantisation of angular momentum holds good for this electron, find :

Q16. The allowed values of the radius 'r' of the orbit $\left(\text{here } a_0 = \sqrt{\frac{h}{2\pi eB}}\right)$.

(A) $r = \sqrt{n}a_0$ (B) $r = \frac{1}{2}\sqrt{n}a_0$

(C) $r = 2\sqrt{n}a_0$ (D) None of these

Q17. The time period of revolution of electron in n^{th} orbit is :-

(A) $\frac{3\pi m}{eB}$ (B) $\frac{\pi m}{eB}$

(C) $\frac{\pi m}{2eB}$ (D) $\frac{2\pi m}{eB}$

Q18. The total magnetic flux due to the magnetic field B passing through the nth orbit.

(A) $\phi = \frac{2nh}{e}$ (B) $\phi = \frac{nh}{e}$

(C) $\phi = \frac{nh}{2e}$ (D) $\phi = \frac{4nh}{e}$

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q19. When we write expression for energy of electron in n^{th} orbit of helium ion (He^+) we take zero potential energy for $n = \infty$, but the potential energy depends on reference. If we take total energy of atom for n = 1 orbit as zero then

Column–I	**Column–II**
(A) Total energy of electron in n = 2	(P) 54.4 eV
(B) Ionization energy from ground state	(Q) 40.8 eV
(C) Energy required to exit electron from n = 1 to n = 2	(R) depends on reference level
(D) Negative of potential energy of electron in n = 1	(S) independent of reference level.
	(T) 70.3 eV

Q20. The energy, the magnitude of linear momentum, magnitude of angular momentum and orbital radius of an electron in a hydrogen atom corresponding to the quantum number n are E, p, L and r respectively. Then according to Bohr's theory of hydrogen atom, match the expressions in column-I with statement in column-II.

Column-I	**Column-II**
(A) Epr	(P) is independent of n.
(B) $\frac{p}{E}$	(Q) is directly proportional to n
(C) Er	(R) is inversely proportional to n.
(D) pr	(S) is directly proportional to L.

NUMERICAL TYPE

Q21. An electron in the nth excited state in a hydrogen atom comes down to the first excited state by emitting 10 different wavelengths. Find the value of n (an integer).

Q22. Find the recoil speed (appoximately in m/sec) when a hydrogen atom emits a photon during the transition from n = 5 to n = 1.

SUBJECTIVE TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q23. Find the longest and shortest wavelength when a hydrogen atom in the ground state is excited by radiations of wavelength 975 Å.

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	A	A	D	C	C	D	C	D	D
11	**12**	**13**	**14**	**15**	**16**	**17**			
D	C	D	A	C	B	B			

Ex-1A

1. A,C,D **2.** B **3.** A,B,C,D **4.** A,C,D **5.** C

6. A,C,D **7.** B **8.** B **9.** C **10.** B

11. (A) $\rightarrow$(P,R) ; (B) $\rightarrow$(Q,S) ; (C) $\rightarrow$(Q, S) ; (D)$\rightarrow$(P,R)

12. 16 : 1 **13.** 121 nm. **14.** $\frac{Rh}{M}\left(\frac{5}{36}\right)$

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	D	D	C	B	A	C	A	B	A
11									
A									

Ex-2A

1. A,D **2.** A,D **3.** A,C,D **4.** C **5.** B

6. A **7.** B **8.** B,C,D **9.** A,B **10.** A,B,D

11. A,B **12.** A **13.** A **14.** B **15.** A

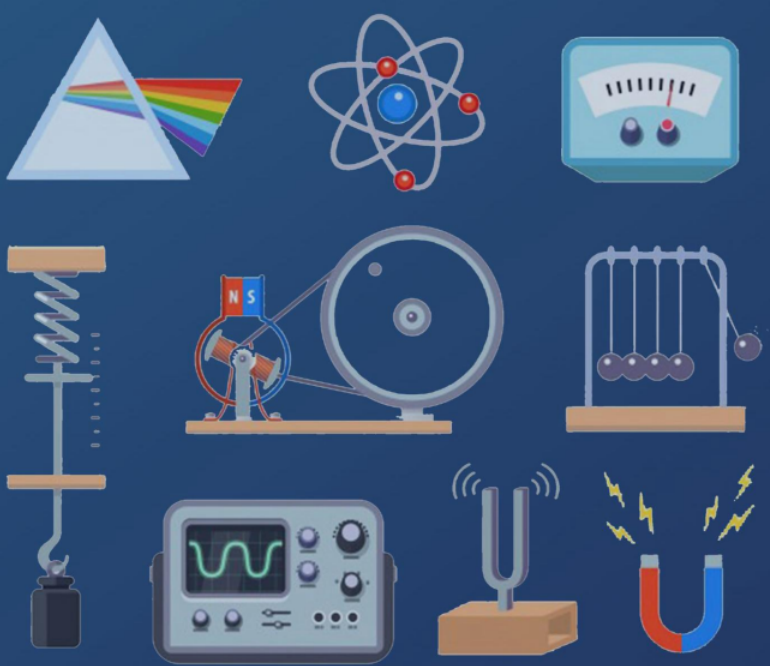
16. A **17.** D **18.** C **19.** (A)-QR, (B)-PS, (C)-QS, (D)-PR

20. (A)-R, (B)-Q,S (C)-P, (D)-Q,S **21.** 6 **22.** 4

23. $\lambda_{max} = 18787.8$ Å, $\lambda_{min} = 975$ Å

PHYSICS

Calorimetry



SHEET

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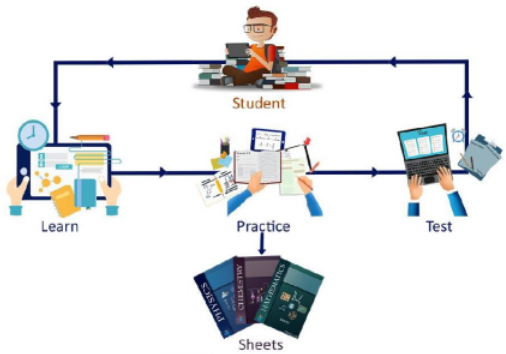
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Introduction to Calorimetry	1-2	6	1,2	1
2	Principle of Calorimetry	3	1,3,5	3,4	4
3	Change of State	4-7	2,4,7	5-8	2,3,5,6,7

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Introduction to Calorimetry

Q1. Heat is associated with

(A) kinetic energy of random motion of molecules.

(B) kinetic energy of orderly motion of molecules.

(C) total kinetic energy of random and orderly motion of molecules.

(D) kinetic energy of random motion in some cases and kinetic energy of orderly motion in other.

Q2. Calorie is defined as the amount of heat required to raise temperature of 1 g of water by 1°C and it is defined under which of the following conditions :–

(A) From 14.5°C to 15.5°C at 760 mm of Hg

(B) From 98.5°C to 99.5°C at 760 mm of Hg

(C) From 13.5°C to 14.5°C at 76 mm of Hg

(D) From 3.5°C to 4.5°C at 76 mm of Hg

Principle of Calorimetry

Q3. 1 kg of ice at – 10°C is mixed with 4.4 kg of water at 30°C. The final temperature of mixture is :

(specific heat of ice is 2100 J/kg/k)

(A) 2.3°C

(B) 4.4°C

(C) 5.3°C

(D) 8.7°C

Change of State

Q4. A block of mass 2.5 kg is heated to temperature of 500°C and placed on a large ice block. What is the maximum amount of ice that can melt (approx.). Specific heat for the body = 0.1 Cal/gm°C.

(A) 1 kg

(B) 1.5 kg

(C) 2 kg

(D) 2.5 kg

Q5. 10 gm of ice at 0°C is kept in a calorimeter of water equivalent 10 gm. How much heat should be supplied to the apparatus to evaporate the water thus formed? (Neglect loss of heat)

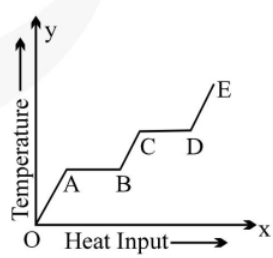
(A) 6200 cal

(B) 7200 cal

(C) 13600 cal

(D) 8200 cal

Q6. A solid material is supplied with heat at a constant rate. The temperature of material is changing with heat input as shown in the figure. What does slope DE represents?



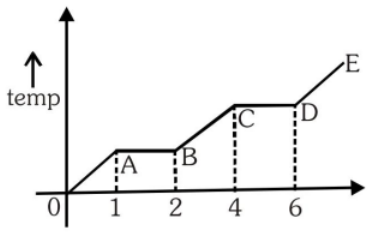
(A) latent heat of liquid

(B) latent heat of vapour

(C) heat capacity of vapour

(D) inverse of heat capacity of vapour

Q7. **Statement–1 :** A solid material is supplied heat at a constant rate. The temp. of the material is changing with the heat input as shown in figure. Latent heat of vaporization of substance is double that of fusion (given CD = 2AB).



Statement–2 : $L_f \propto AB$ and $L_v \propto CD$

(A) Statement–1 is True, Statement–2 is True ; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is True ; Statement–2 is not a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. When two samples at different temperatures are mixed, the temperature of the mixture can be :-

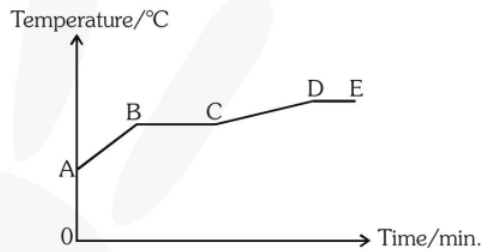
(A) lesser than lower or greater than higher temperature

(B) equal to lower or higher temperature

(C) greater than lower but lesser than higher temperature

(D) average of lower and higher temperatures.

Q2. A well insulated substance in solid state is heated at a constant rate until it vaporizes completely. The temperature-time graph of the substance is shown below. Which of the following statements is/are true ?



(A) The specific heat capacity of the substance in solid state is greater than that of the substance in liquid state.

(B) The specific latent heat of fusion of the substance is greater than the specific latent heat of vaporization of the substance.

(C) If the rate of heating increases, the slope of AB will be increased but the length of BC remains unchanged.

(D) If the mass of the substance is doubled, the length of DE is also doubled but the slope of CD is halved.

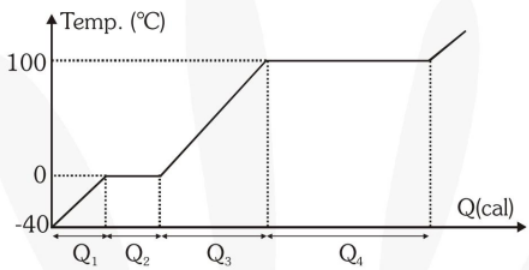
MATCH THE COLUMN TYPE

Following questions contain statements given in two columns, which have to be matched. The statements in ***Column-I*** *are labelled as A, B, C and D while the statements in* ***Column-II*** *are labelled as (P), (Q), (R) and (S). Any given statement in* ***Column-I*** *can have correct matching with* ***ONE OR MORE*** *statement(s) in* ***Column-II****.*

Q3. Three liquids A, B and C having same specific heat and mass m, 2m and 3m have temperature 20°C, 40°C and 60°C respectively. Temperature of the mixture when :

Column I	Column II
(A) A and B are mixed	(P) 35°C
(B) A and C are mixed	(Q) 52°C
(C) B and C are mixed	(R) 50°C
(D) A, B and C all three are mixed	(S) 45°C
	(T) None

Q4. Figure shows the temperature variation when heat is added continuously to a specimen of ice (10 g) at –40 °C at constant rate. (Specific heat of ice is 0.53 cal/g °C and L_{ice} = 80 cal/g, L_{water} = 540 cal/g)



Column–I	Column–II
(A) Value of Q_1 (in cal)	(P) 800
(B) Value of Q_2 (in cal)	(Q) 1000
(C) Value of Q_3 (in cal)	(R) 5400
(D) Value of Q_4 (in cal)	(S) 212
	(T) 900

(A) A→S; B→P; C→Q; D→T
(B) A→P; B→S; C→Q; D→R
(C) A→P; B→S; C→R; D→Q
(D) A→S; B→P; C→Q; D→R

SUBJECTIVE TYPE

Q5. Two identical calorimeter A and B contain equal quantity of water at 20°C. A 5 gm piece of metal X of specific heat 0.2 cal g^{-1} $(C°)^{-1}$ is dropped into A and a 5 gm piece of metal Y into B. The equilibrium temperature in A is 22°C and in B 23°C. The initial temperature of both the metals is 40°C. Find the specific heat of metal Y in cal g^{-1} $(C°)^{-1}$.

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q6. Calculate heat required in cal to raise the temperature of 1 g of water through 1°C ?

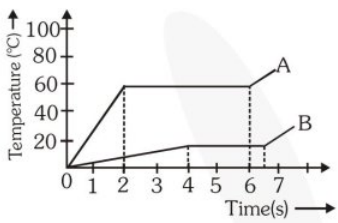
Q7. Find Heat releases by 1 kg steam at 150°C if it convert into 1 kg water at 50°C (in k cal).

Exercise - 2 — Brain Booster

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Two substances A and B of equal mass m are heated by uniform rate of 6 cal s^{-1} under similar conditions. A graph between temperature and time is shown in figure. Ratio of heat absorbed H_A / H_B by them during complete fusion is :-



(A) $\frac{9}{4}$ (B) $\frac{4}{9}$ (C) $\frac{8}{5}$ (D) $\frac{5}{8}$

Q2. The density of a material A is 1500 kg/m^3 and that of another material B is 2000 kg/m^3. It is found that the heat capacity of 8 volumes of A is equal to heat capacity of 12 volumes of B. The ratio of specific heats of A and B will be

(A) 1 : 2 (B) 3 : 1 (C) 3 : 2 (D) 2 : 1

Q3. Some steam at 100°C is passed into 1.1 kg of water contained in a calorimeter of water equivalent 0.02 kg at 15°C so that the temperature of the calorimeter and its contents rises to 80°C. What is the mass of steam condensing. (in kg)

(A) 0.130 (B) 0.065
(C) 0.260 (D) 0.135

Q4. A continuous flow water heater (geyser) has an electrical power rating = 2 kW and efficienty of conversion of electrical power into heat = 80%. If water is flowing through the device at the rate of 100 cc/sec, and the inlet temperature is 10°C, the outlet temperature will be

(A) 12.2°C (B) 13.8°C
(C) 20°C (D) 16.5°C

Q5. 540 g of ice at 0°C is mixed with 540 g of water at 80°C. The final temperature of the mixture is (Given latent heat of fusion of ice = 80 cal/g and specific heat capacity of water = 1 cal/g^{0}C)

(A) 0°C (B) 40°C
(C) 80°C (D) less than 0°C

Q6. 2 kg of ice at –20°C is mixed with 5 kg of water at 20°C in an insulating vessel having a negligible heat capacity. Calculate the final mass of water remaining in the container. It is given that the specific heats of water and ice are 1 kcal/kg/°C while the latent heat of fusion of ice is 80 kcal/kg :-

(A) 7 kg (B) 6 kg
(C) 4 kg (D) 2 kg

Q7. Ice at 0°C is added to 200 g of water initially at 70°C in a vacuum flask. When 50 g of ice has been added and has all melted the temperature of the flask and contents is 40°C. When a further 80g of ice has been added and has all metled, the temperature of the whole is 10°C. Calculate the specific latent heat of fusion of ice.

[Take S_w =1 cal /gm °C.]

(A) 3.8 ×10^5 J/ kg (B) 1.2 ×10^5 J/ kg
(C) 2.4 ×10^5 J/ kg (D) 3.0 ×10^5 J/ kg

Q8. In an insulated vessel, 0.05 kg steam at 373 K and 0.45 kg of ice at 253 K are mixed. Then, find the final temperature of the mixture.

Given,

L_{fusion} = 80 cal/g = 336 J/g,

$L_{vaporization}$ = 540 cal/g = 2268 J/g,

S_{ice} = 2100 J/kg K = 0.5 cal/gK and

S_{water} = 4200 J/kg K = 1 cal /gK

(A) 273 K (B) 373 K
(C) 100 K (D) 0 K

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Equal amount of heat energy are transferred into equal mass of ethyl alcohol and water sample. The rise in temperature of water sample is 25°C. The temperature rise of ethyl alcohol will be.

(Specific heat of ethyl alcohol is one half of the specific heat of water).

(A) 12.5°C

(B) 25°C

(C) 50°C

(D) It depends on the rate of energy transfer.

Q2. 50 gm ice at – 10°C is mixed with 20 gm steam at 100°C. When the mixture finally reaches its steady state inside a calorimeter of water equivalent 1.5 gm then : [Assume calorimeter was initially at 0°C, Take latent heat of vaporization of water = 540 cal/gm, Latent heat of fusion of water = 80 cal/gm, specific heat capacity of water = 1 cal/gm-°C, specific heat capacity of ice = 0.5 cal/gm°C]

(A) Mass of water remaining is : 67.4 gm

(B) Mass of steam remaining is : 2.6 gm

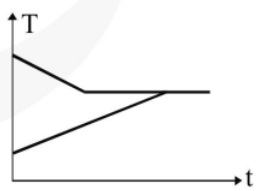
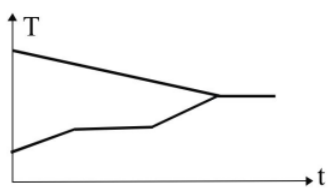
(C) Mass of water remaining is : 67.87 gm

(D) Mass of steam remaining is : 2.13 gm

MATCH THE COLUMN TYPE

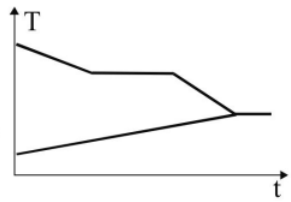
Following questions contain statements given in two columns, which have to be matched. The statements in ***Column-I*** *are labelled as A, B, C and D while the statements in* ***Column-II*** *are labelled as (P), (Q), (R) and (S). Any given statement in* ***Column-I*** *can have correct matching with* ***ONE OR MORE*** *statement(s) in* ***Column-II****.*

Q3. A sample 'A' of liquid water and a sample B of ice of equal mass are kept in 2 nearby containers so that they can exchange heat with each other but are thermally insulated from the surroundings. The graphs in column-II show the sketch of temperature T of samples versus time t. Match with appropriate description in column-I.

Column I	**Column II**
(A) Equilibrium temperature is above melting point of ice.	(P) 
(B) At least some of water freezes.	(Q) 

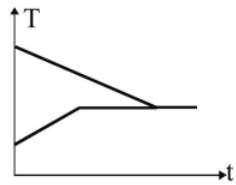
(C) At least some of ice melts.

(R)

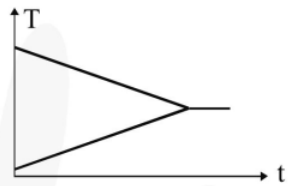


(D) Equilibrium temperature is below freezing point of water

(S)



(T)



NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q4. A flow calorimeter is used to measure the specific heat of a liquid. Heat is added at a known rate to a stream of the liquid as it passes through the calorimeter at a known rate. Then a measurement of the resulting temperature difference between the inflow and the outflow points of the liquid stream enables us to compute the specific heat of the liquid. A liquid of density 0.2 g/cm^3 flows through a calorimeter at the rate of 10 cm^3/s. Heat is added by means of a 250-W electric heating coil, and a temperature difference of 25°C is established in steady-state conditions between the inflow and the outflow points. Find the specific heat of the liquid (in J/°C kg.)

Q5. An aluminium container of mass 100 gm contains 200 gm of ice at – 20°C. Heat is added to the system at the rate of 100 cal/s. Find the temperature of the system (in °C) after 4 minutes.

(Given : specific heat of ice = 0.5 cal/gm/°C and L = 80 cal/gm, specific heat of Al = 0.2 cal/gm/°C)

SUBJECTIVE TYPE

Q6. A block of ice with mass m falls into a lake. After impact, a mass of ice $m/5$ melts. Both the block of ice and the lake have a temperature of 0°C. If L represents the latent heat of fusion, the minimum distance the ice fell before striking the surface is

Q7. 5 gm of steam at 100°C is mixed with 10gm of ice at 0°C. Find the final composition of mixture.

Answer Key

Ex-1						
1	**2**	**3**	**4**	**5**	**6**	**7**
A	A	D	B	D	D	A

Ex-1A

1. B,C,D **2.** B,D **3.** (A) T (B) R, (C) Q, (D) T **4.** D

5. 27/85 **6.** 1 cal **7.** 615 Kcal.

Ex-2							
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
C	D	A	B	A	B	A	A

Ex-2A

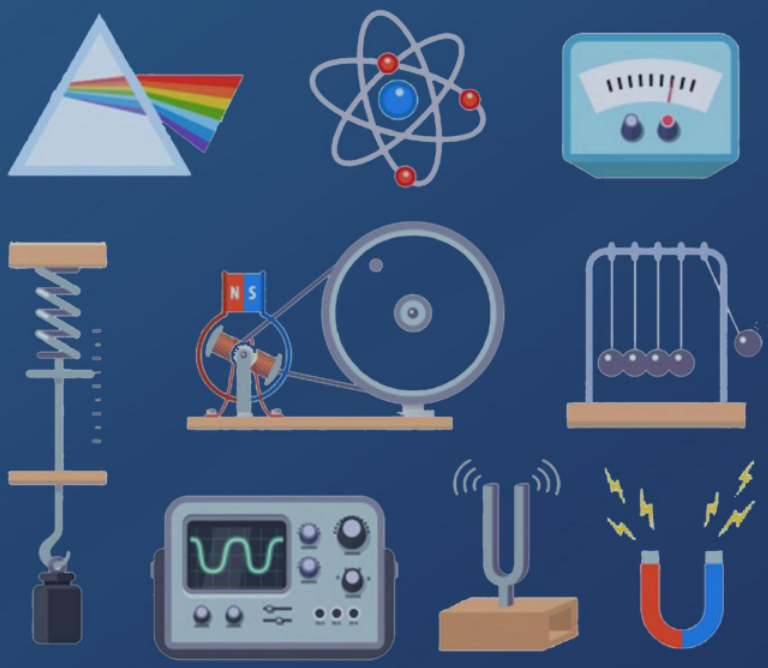
1. C **2.** A,B **3.** A - Q ; B - P,R ; C - Q,S ; D - R

4. 5000 J/°C kg **5.** 25.5°C **6.** $\frac{L}{5g}$ **7.** 1.67 gm of steam +13.33 gm of H_2O

-: Important Notes & Formulas :-

PHYSICS

Capacitor



SHEET

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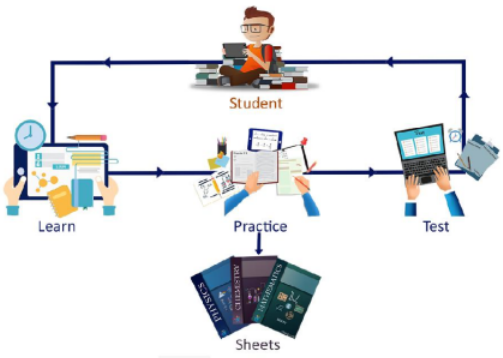
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Capacitor Introduction	1	15,16		11
2	Parallel Plate Capacitor	2	2		1,12
3	Series and Parallel combination	3-6			
4	Circuit Analysis- mesh and nodal analysis	7-9			2
5	Energy stored in capacitor	10,11			
6	Charge flow and heat loss	12-16	1,2	1-4	3
7	Equivalent capacitance and parallel plate	17	17,22	5,6	
8	Dielectric		3,18	7,8	
9	Differet combinations of dielectric	18-22		9	4
10	Electric force on dielectric slab			10,11	5
11	Transient state capacitor	23	4,9,10, 11-14		
12	Calculation of current at different state		5,6	12	6-9
13	Discharging of capacitor	24	7,8,19	13,14	
14	After full chapter	25	20,23	15	10

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Capacitor Introduction

Q1. The earth has Volume 'V' and Surface area 'A' then capacitance would be :

(A) $4\pi\epsilon_0 \frac{A}{V}$ (B) $4\pi\epsilon_0 \frac{V}{A}$

(C) $12\pi\epsilon_0 \frac{V}{A}$ (D) $12\pi\epsilon_0 \frac{A}{V}$

Parallel Plate Capacitor

Q2. **Statement–1 :** The capacitance of a capacitor depends on the shape, size and geometrical placing of the conductors and its medium between them.

Statement–2 : When a charge q passes through a battery of emf E from the negative terminal to an positive terminal, an amount qE of work is done by the battery.

(A) Statement-1 is True, Statement–2 is True; Statement-2 is a correct explanation for Statement-1

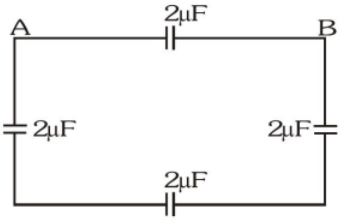
(B) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Series and Parallel combination

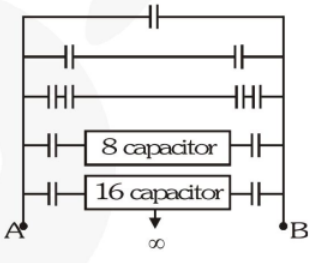
Q3. The equivalent capacitance between the points A and B in the given diagram is :



(A) 8 μF (B) 6 μF

(C) $\frac{8}{3}\mu F$ (D) $\frac{3}{8}\mu F$

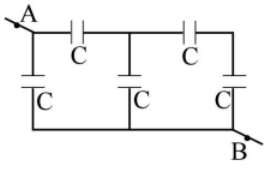
Q4. An infinite number of identical capacitors each of capacitance 1μ F are connected as in adjoining figure. Then the equivalent capacitance between A and B is :



(A) 1μ F (B) 2μ F

(C) $\frac{1}{2}\mu F$ (D) ∞

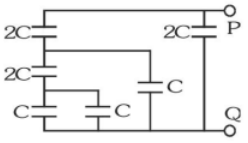
Q5. What is the equivalent capacitance of the system of capacitors between A & B as shown in the figure.



(A) $\frac{7}{6}C$ (B) 1.6 C

(C) C (D) None

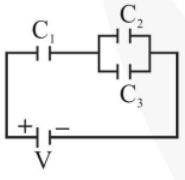
Q6. The value of equivalent capacitance of the combination shown in figure between the points P and Q is :–



(A) 3 C (B) 2 C (C) C (D) C/3

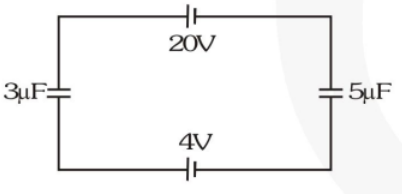
Circuit Analysis - mesh and nodal analysis

Q7. Capacitance $C_1 = 2C_2 = 2C_3$ and potential difference across C_1, C_2 & C_3 are V_1, V_2 & V_3 respectively then :-



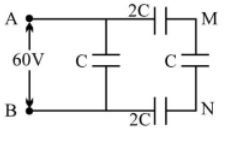
(A) $V_1 = V_2 = V_3$
(B) $V_1 = 2V_2 = 2V_3$
(C) $2V_1 = V_2 = V_3$
(D) $2V_1 = 2V_2 = V_3$

Q8. In the given circuit, the potential difference across 3 μF capacitor will be :



(A) 16 V (B) 10 V (C) 6 V (D) 4 V

Q9. In the circuit shown, a potential difference of 60V is applied across AB. The potential difference between the point M and N is

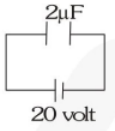


(A) 10 V (B) 15 V
(C) 20 V (D) 30 V

Energy stored in capacitor

Q10. A glass slab is put within the plates of a charged parallel plate condenser. Which of the following quantities does not change :
(A) energy of the condenser
(B) capacity
(C) intensity of electric field
(D) charge

Q11. In the figure a capacitor of capacitance 2μF is connected to a cell of emf 20 volt. The plates of the capacitor are drawn apart slowly to double the distance between them, The work done by the external agent on the plates is :

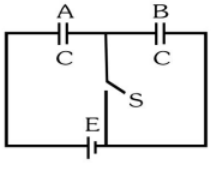


(A) – 200μJ (B) 200μJ
(C) 400μJ (D) – 400μJ

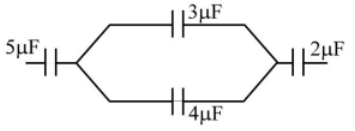
Charge Flow and Heat Loss

Q12. A parallel plate capacitor is charged with a battery and afterwards the battery is removed. If now with the help of insulating handles, the distance between plates is increased, then
(A) charge on capacitor increases and capacity decreases.
(B) potential difference between plates increases.
(C) capacity of capacitor increases.
(D) value of energy stored in capacitor decreases.

Q13. Consider the situation shown. The switch S is open for a long time and then closed. The charge flown through the battery when S is closed :
(A) CE
(B) CE / 2
(C) CE / 3
(D) CE / 4

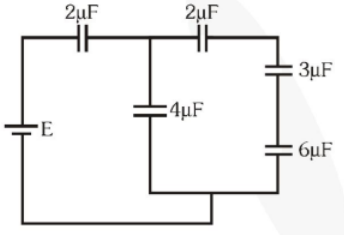


Q14. If charge on left plate of the 5μF capacitor in the circuit segment shown in the figure is –20μC, the charge on the right plate of 3μF capacitor is :-



(A) +8.57 μC (B) –8.57 μC
(C) +11.42 μC (D) –11.42 μC

Q15. In the given circuit if charge on 6μF capacitor is 10 μC, then charge on 4 μF capacitor will be :



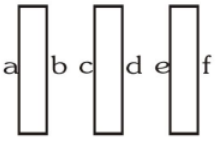
(A) 40 μC (B) 10 μC
(C) 20 μC (D) 30 μC

Q16. A capacitor of capacitance C is initially charged to a potential difference of V volt. Now it is connected to a battery of 2V Volt with opposite polarity. The ratio of heat generated to the final energy stored in the capacitor will be

(A) 1.75 (B) 2.25 (C) 2.5 (D) 1/2

Equivalent capacitance and parallel plate

Q17. Three parallel metallic plates, each of area A are kept as shown in the figure and charges Q_1, Q_2 and Q_3 are given to them. Edge effects are negligible. Calculate the charges on the two outermost surfaces 'a' and 'f'.



(A) $\frac{Q_1+Q_2+Q_3}{2}$ (B) $\frac{Q_1+Q_2+Q_3}{3}$

(C) $\frac{Q_1-Q_2+Q_3}{3}$ (D) $\frac{Q_1-Q_2+Q_3}{2}$

Differet Combinations of Dielectric

Q18. If the maximum circumference of a sphere is 2m, then capacitance of sphere in water would be nearly :

(Dielectric constant of water = 81)

(A) 270 pF (B) 2600 pF
(C) 28 pF (D) 2800 pF

Q19. **Statement–1:** Capacitor is filled with same thickness of dielectric (t < d) and conducting sheet one after another, then capacitance are C_1 and C_2 respectively then $C_1 < C_2$.

Statement–2: Capacitance is more in presence of metal sheet in compare to dielectric sheet as $K_{Conduct} > K_{dielectric}$.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement-1

(B) Statement–1 is True, Statement–2 is True; Statement–2 is NOT a correct explanation for Statement–1

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Q20. Distance between plates of a parallel plate capacitor is 'd' and area of each plate is A. When a slab of dielectric constant K and thickness t is placed between the plates, its capacity becomes:

(A) $\frac{\varepsilon_0 A}{\left[d+t\left\{1-\frac{1}{K}\right\}\right]}$ (B) $\frac{\varepsilon_0 A}{\left[d+t\left\{1+\frac{1}{K}\right\}\right]}$

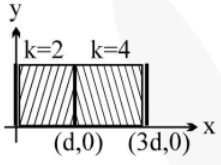
(C) $\frac{\varepsilon_0 A}{\left[d-t\left\{1+\frac{1}{K}\right\}\right]}$ (D) $\frac{\varepsilon_0 A}{\left[d-t\left\{1-\frac{1}{K}\right\}\right]}$

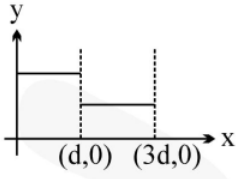
Q21. A capacitor stores 60μC charge when connected across a battery. When the gap between the plates is filled with a dielectric, a charge of 120μC flows through the battery. The dielectric constant of the material inserted is :

(A) 1 (B) 2

(C) 3 (D) none

Q22. A parallel plate capacitor has two layers of dielectric as shown in figure. This capacitor is connected across a battery. The graph which shows the variation of electric field (E) and distance (x) from left plate is -



(A)


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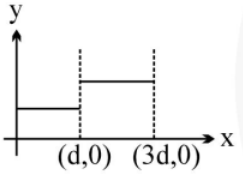

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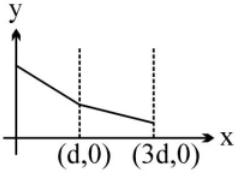

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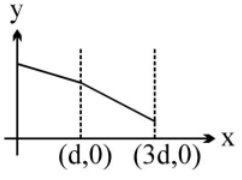
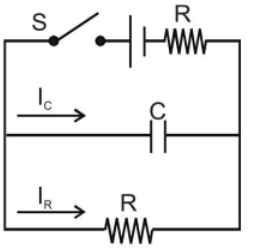


Transient state capacitor

Q23. Consider the circuit below, with an initially uncharged capacitor and two identical resistors. At the instant the switch is closed:



(A) $I_R = I_C = 0$

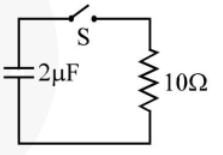
(B) $I_R = \varepsilon/2R$; $I_C = 0$

(C) $I_R = 0$; $I_C = \varepsilon/R$

(D) $I_R = \varepsilon/2R$; $I_C = \varepsilon/R$

Discharging of Capacitor

Q24. In the R–C circuit shown in the figure the total energy of 3.6×10^{-3} J is dissipated in the 10 Ω resistor when the switch S is closed. The initial charge on the capacitor is



(A) 60 μC (B) 120 μC

(C) $60\sqrt{2}$ μC (D) $\frac{60}{\sqrt{2}}$ μC

After Full Chapter

Q25. Three capacitors 2 μF, 3 μF and 5 μF can withstand voltages to 3V, 2V and 1V respectively. Their series combination can withstand a maximum voltage equal to

(A) 5 Volts

(B) (31/6) Volts

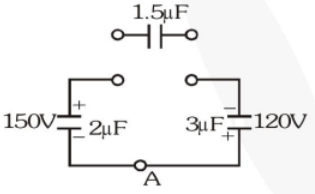
(C) (26/5) Volts

(D) None

ONE OR MORE THAN ONE CORRECT TYPE

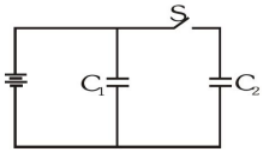
*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Two capacitors of 2μF and 3μF are charged to 150 volt and 120 volt respectively. The plates of capacitor are connected as shown in the figure. A discharged capacitor of capacity 1.5μF falls to the free ends of the wire. Then –



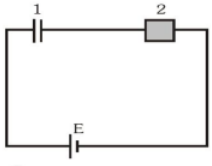
(A) charge on the 1.5μF capacitor is 180μC
(B) charge on the 2μF capacitor is 120 μC
(C) charge flows through A from right to left
(D) charge flows through A from left to right.

Q2. Two capacitors of equal capacitance (C_1=C_2) are shown in the figure. Initially, while the switch S is open, one of the capacitors is uncharged and the other carries charge Q_0. The energy stored in the charged capacitor is U_0. Sometimes after the switch is closed, the capacitors C_1 and C_2 carry charges Q_1 and Q_2 respectively; the voltage across the capacitors are V_1 and V_2; and the energies stored in the capacitors are U_1 and U_2. Which of the following statements is correct ?



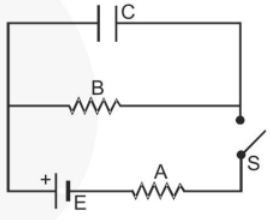
(A) $Q_0 = \frac{1}{2}(Q_1 + Q_2)$ (B) $Q_1 = Q_2$
(C) $V_1 = V_2$ (D) $U_1 = U_2$

Q3. Two identical capacitors 1 and 2 are connected in series to a battery as shown in figure. Capacitor 2 contains a dielectric slab of dielectric constant k as shown. Q_1 and Q_2 are the charges stored in the capacitors. Now the dielectric slab is removed and the corresponding charges are Q'_1 and Q'_2. Then-



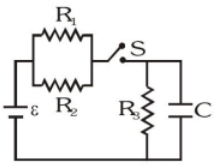
(A) $\frac{Q'_1}{Q_1} = \frac{k+1}{k}$ (B) $\frac{Q'_2}{Q_2} = \frac{k+1}{2}$
(C) $\frac{Q'_2}{Q_2} = \frac{k+1}{2k}$ (D) $\frac{Q'_1}{Q_1} = \frac{k}{2}$

Q4. In the circuit shown, A and B are equal resistances. When S is closed, the capacitor C charges from the cell of emf E and reaches a steady state



(A) During charging, more heat is produced in A than in B.
(B) In the steady state, heat is produced at the same rate in A and B.
(C) In the steady state, energy stored in C is 1/4 CE^2.
(D) In the steady state, energy stored in C is 1/8 CE^2

Q5. The circuit shown in the figure consists of a battery of emf ε=10 V; a capacitor of capacitance C =1.0 μF and three resistor of values R_1 = 2Ω, R_2 = 2Ω and R_3 = 1Ω. Initially the capacitor is completely uncharged and the switch S is open. The switch S is closed at t = 0.



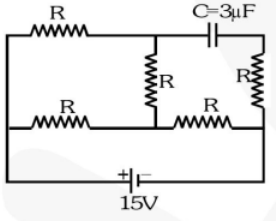
(A) The current through resistor R_3 at the moment the switch closed is zero

(B) The current through resistor R_3 a long time after the switch closed is 5A.

(C) The ratio of current through R_1 and R_2 is always constant

(D) The maximum charge on the capacitor during the operation is 5μC

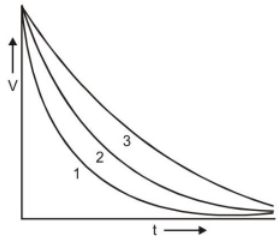
Q6. In the circuit shown, the cell is ideal, with emf = 15V. Each resistance is of 3Ω. After long time The potential difference across the capacitor is



(A) zero (B) 9V

(C) 12V (D) 15V

Q7. Three identical capacitors A, B and C are charged to the same potential and then made to discharge through three resistances R_A, R_B and R_C, where $R_A > R_B > R_C$. Their potential differences (V) are plotted against time t, giving the curves 1, 2 and 3. The relations between A, B, C and 1, 2, 3 is/are -



(A) 1 → A (B) 2 → B

(C) 1 → C (D) 3 → A

Q8. Capacitors $C_1 = 1\mu F$ and $C_2 = 2\mu F$ are separately charged from the same battery. They are then allowed to discharge separately through equal resistors–

(A) The currents in the two discharging circuits at t = 0 is zero.

(B) The currents in the two discharging circuits at t = 0 are equal but not zero.

(C) The currents in the two discharging circuits at t = 0 are unequal.

(D) C_1 loses 50% of its initial charges sooner than C_2 loses 50% of its initial charge.

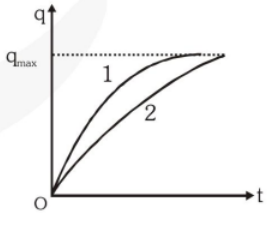
PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 9 & 10

The charge across the capacitor in two different RC circuits 1 and 2 are plotted as shown in figure.

Q9. Choose the correct statement (s) related to the two circuits.



(A) Both the capacitors are charged to the same charge.

(B) The emf's of cells in both the circuit are equal.

(C) The emf's of the cells may be different.

(D) The emf E_1 is more than E_2

Q10. Identify the correct statement(s) related to the R_1, R_2, C_1 and C_2 of the two RC circuits if time constant of second circuit is more than first circuit.

(A) $R_1 > R_2$ if $E_1 = E_2$

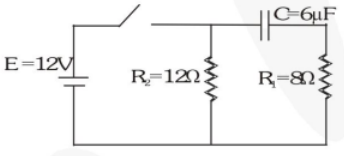
(B) $C_1 < C_2$ if $E_1 = E_2$

(C) $R_1C_1 > R_2C_2$

(D) $\frac{R_1}{R_2} < \frac{C_2}{C_1}$

Paragraph for Question No. 11 & 14

The circuit contains ideal battery E and other elements arranged as shown. The capacitor is initially uncharged and switch S is closed at t = 0, (use $e^2 = 7.4$):



Q11. Time constant of the circuit is:

(A) 48 μs (B) 28.8 μs

(C) 72 μs (D) 120 μs

Q12. The potential difference across the capacitor in volts, after two time constants, is :

(A) 2 (B) 7.6

(C) 10.4 (D) 12

Q13. The potential difference across resistor R_1 in volts after two time constants, is :

(A) 1.6 (B) 7.6

(C) 10 (D) 12

Q14. The potential difference across resistor R_2 in volts after two time constants, is:

(A) 2 (B) 7.6

(C) 10 (D) 12

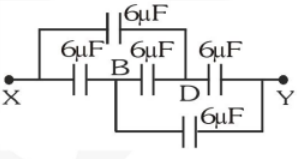
NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q15. A conductor gets a charge of 50 μC when it is connected to a battery of e.m.f. 5 V. Calculate capacity of the conductor.

Q16. Two conductors having capacities 2μF and 5μF and potentials 2 volt and 10 volt respectively. Calculate the ratio of their charges after connecting by a wire.

Q17. What is the effective capacitance between points X and Y ?



Q18. The capacity of a spherical capacitor in air is 50 μF and on immersing it into oil it becames 110 μF. Calculate the dielectric constant of oil.

Q19. The plates of a capacitor are charged to a potential difference of 100 V and then connected across a resister. The potential difference across the capacitor decays exponentially with respect to time. After one second the potential difference between the plates of the capacitor is 80 V. What is the fraction of the stored energy which has been dissipated ?

Q20. A parallel-plate capacitor is formed by two plates, each of area 100 cm^2, separated by a distance of 1mm. A dielectric of dielectric constant 5.0 and dielectric strength 1.9×10^7 V/m is filled between the plates. Find the maximum charge that can be stored on the capacitor without causing any dielectric breakdown.

SUBJECTIVE TYPE

Q21. If the distance between the plates of a parallel plate capacitor is made half and the area of plates is doubled then what will be the capacitance.

Q22. An infinite number of capacitors of capacitance C, 4C, 16C ... ∞ are connected in series then what will be their resultant capacitance ?

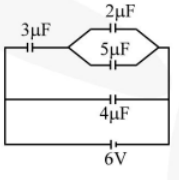
Q23. A parallel plate capacitor of capacity C is connected to a battery and is charged to potential V, another condenser of capacity 2C is connected to another battery and is charged to potential 2V the charging batteries are removed and now the condensers are connected in parallel in such a way that the positive plate of one is connected to negative plate of another. Calculate final energy of the system.

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

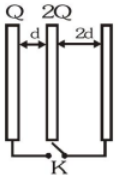
Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. In the circuit shown in figure, the ratio of charges on 5μF and 4μF capacitor is :-



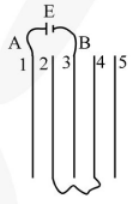
(A) 4/5 (B) 3/5
(C) 3/8 (D) 1/2

Q2. Three large plates are arranged as shown. How much charge will flow through the key k if it is closed ?



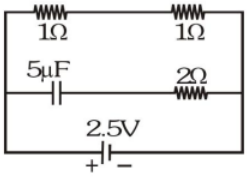
(A) $\frac{5Q}{6}$ (B) $\frac{4Q}{3}$
(C) $\frac{3Q}{2}$ (D) None of these

Q3. Five conducting parallel plates having area A and separation between them d, are placed as shown in the figure. Plate number 2 and 4 are connected wire and between point A and B, a cell of emf E is connected. The charge flown through the cell is



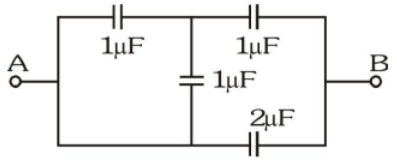
(A) $\frac{3}{4}\frac{\varepsilon_0 AE}{d}$ (B) $\frac{2}{3}\frac{\varepsilon_0 AE}{d}$
(C) $\frac{4\varepsilon_0 AE}{d}$ (D) $\frac{\varepsilon_0 AE}{2d}$

Q4. A capacitor of capacitance 5 μF is connected as shown in the figure The internal resistance of the cell is 0.5 Ω. The amount of charge on the capacitor plate is :-



(A) 0 μC (B) 5 μC
(C) 10 μC (D) 25 μC

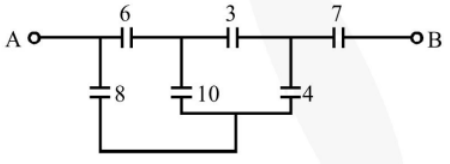
Q5. The equivalent capacitance of the circuit shown, between points A and B will be



(A) $\frac{2}{3}\mu F$ (B) $\frac{5}{3}\mu F$

(C) $\frac{8}{3}\mu F$ (D) $\frac{7}{3}\mu F$

Q6. In the circuit diagram shown all the capacitors are in mF. The equivalent capacitance between points A & B is (in mF)



(A) 14/5 (B) 7.5

(C) 3/7 (D) None of these

Q7. Two identical parallel plate capacitors are connected in series and then joined with a battery of 100V. A sheet of dielectric constant 4.0 is inserted between the plates of second capacitor. The potential difference across the capacitors will be respectively

(A) 50 V, 50V (B) 80 V, 20 V

(C) 20V, 80V (D) 75 V, 25 V

Q8. Two parallel plate capacitors whose capacities are C and 2 C respectively, are joined in parallel. These are charged by V potential difference. If the battery is now removed and a dielectric of dielectric constant K is filled in between the plates of the capacitor C, then what will be the potential difference across each capacitor ?

(A) $\frac{V}{K+2}$ (B) $\frac{2V}{K+2}$

(C) $\frac{3V}{K+2}$ (D) $\frac{2+K}{3V}$

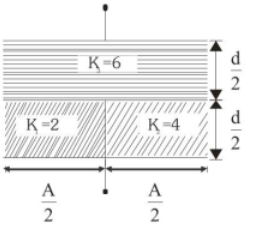
Q9. A parallel plate capacitor of capacitance C (without dielectrics) is filled by dielectric slabs as shown in figure. Then the new capacitance of the capacitor is

(A) 3.9 C

(B) 4 C

(C) 2.4 C

(D) 3 C

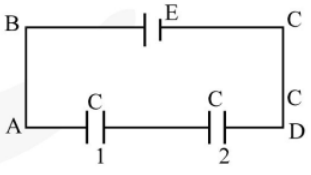


Q10. A parallel plate capacitor of plate area A and plate separation d is charged to potential V and then the battery is disconnected. A slab of dielectric constant k is then inserted between the plates of the capacitors so as to fill the space between the plates. If Q, E and W denote respectively, the magnitude of charge on each plate, the electric field between the plates (after the slab is inserted) and work done on the system in question in the process of inserting the slab, then state incorrect relation from the following :-

(A) $Q=\frac{\varepsilon_0 AV}{d}$ (B) $W=\frac{\varepsilon_0 AV^2}{2kd}$

(C) $E=\frac{V}{kd}$ (D) $W=\frac{\varepsilon_0 AV^2}{2d}\left(1-\frac{1}{k}\right)$

Q11. In the adjoining figure, capacitor (1) and (2) have a capacitance 'C' each. When the dielectric of dielectric consatnt K is inserted between the plates of one of the capacitor, the total charge flowing through battery is-



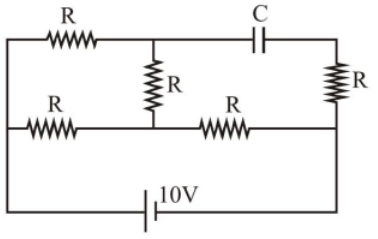
(A) $\frac{KCE}{K+1}$ from B to C

(B) $\frac{KCE}{K+1}$ from C to B

(C) $\frac{(K-1)CE}{2(K+1)}$ from B to C

(D) $\frac{(K-1)CE}{2(K+1)}$ from C to B

Q12. Find the potential difference across the capacitor in volts.



(A) 4V (B) 2V
(C) 1 V (D) 8V

Q13. A capacitor of capacitance C is charged by a battery whose internal resistance is R. The time after which potential difference across resistor becomes n times to that across capacitor is -

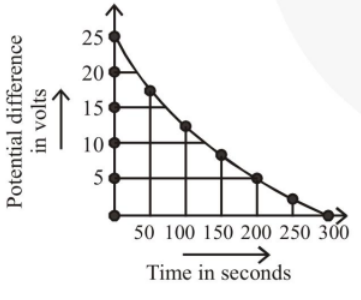
(A) $RC\ell n\left(\frac{1+n}{n}\right)$

(B) $RC\ell n\left(\frac{n}{1+n}\right)$

(C) $RC\ell n\left(\frac{n}{n-1}\right)$

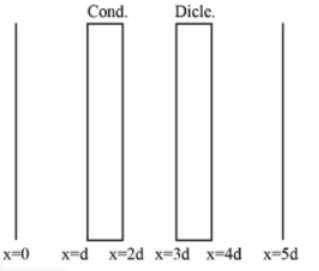
(D) $RC\ell n(1+n)$

Q14. The figure shows an experimental plot discharging of a capacitor in an RC circuit. The time constant t of this circuit lies between -

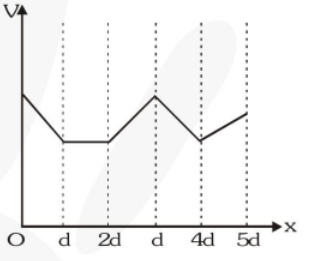


(A) 150 sec and 200 sec
(B) 0 and 50 sec
(C) 50 sec and 100 sec
(D) 100 sec and 150 sec

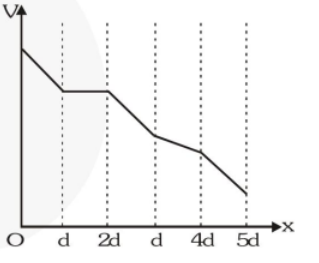
Q15. The distance between plates of a parallel plate capacitor is 5d. The positively charged plate is at x=0 and negatively charged plates is at x=5d. Two slabs one of conductor and the other of a dielectric of same thickness d are inserted between the plates as shown in figure. Potential (V) versus distance x graph will be



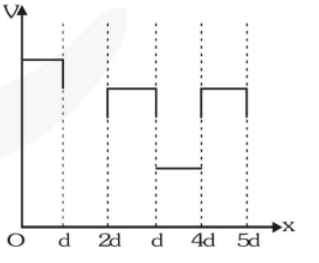
(A)



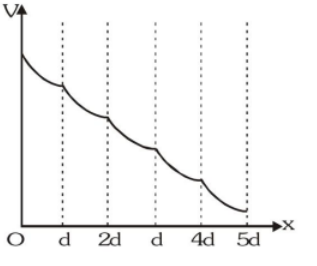
(B)



(C)



(D)



ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Three long concentric conducting cylindrical shells have radii R, 2R and $2\sqrt{2}$ R. Inner and outer shells are connected to each other. The capacitance across middle and inner shells per unit length is:

(A) $\frac{\frac{1}{3}\epsilon_0}{\ln 2}$ (B) $\frac{6\pi\epsilon_0}{\ln 2}$

(C) $\frac{\pi\epsilon_0}{2\ln 2}$ (D) None

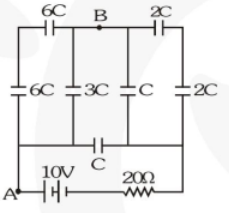
Q2. For the circuit shown here, the potential difference between points A and B is

(A) 2.5 V

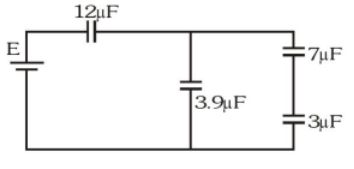
(B) 7.5 V

(C) 10 V

(D) Zero



Q3. Four capacitors and a battery are connected as shown. The potential drop across the 7μF capacitor is 6V. Then the



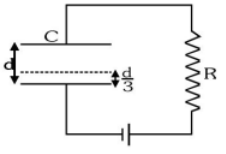
(A) potential difference across the 3μF capacitor is 10V

(B) charge on the 3μF capacitor is 42μC

(C) e.m.f. of the battery is 30V

(D) potential difference across the 12μF capacitor is 10V.

Q4. A parallel plate capacitor C with plates of unit area and separation d is filled with a liquid of dielectric constant K = 2. The level of liquid is $\frac{d}{3}$ initially. Suppose the liquid level decreases at a constant speed v the time constant as a function of time t is :



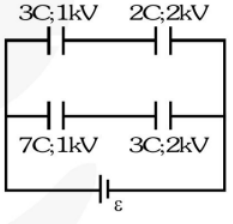
(A) $\frac{6\varepsilon_0 R}{5d+3vt}$

(B) $\frac{(15d+9vt)\varepsilon_0 R}{2d^2-3dvt-9v^2t^2}$

(C) $\frac{6\varepsilon_0 R}{5d-3vt}$

(D) $\frac{(15d-9vt)\varepsilon_0 R}{2d^2+3dvt-9v^2t^2}$

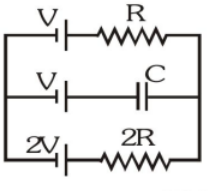
Q5. The diagram shows four capacitors with capacitance and break down voltages as mentioned. What should be the maximum value of the external emf source such that no capacitor breaks down?



(A) 2.5 kV (B) 10/3kV

(C) 3 kV (D) 1 kV

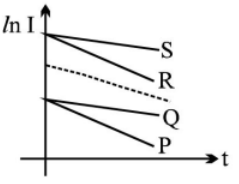
Q6. In the given circuit, with steady current, the potential drop across the capacitor must be:-



(A) V (B) V/2

(C) V/3 (D) 2V/3

Q7. In an RC circuit while charging, the graph of ℓn I versus time is as shown by the dotted line in the adjoining diagram where I is the current. When the value of the resistance is doubled, which of the solid curves best represents the variation of ℓn I versus time?

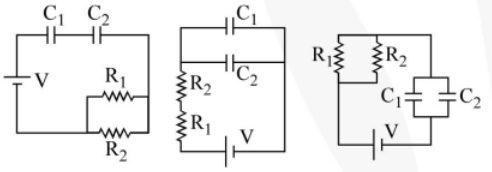


(A) P (B) Q (C) R (D) S

Q8. Given :

$R_1 = 1\Omega$, $R_2 = 2\Omega$, $C_1 = 2\mu F$, $C_2 = 4\mu F$.

The time constants (in μS) for the circuits I, II, III are respectively

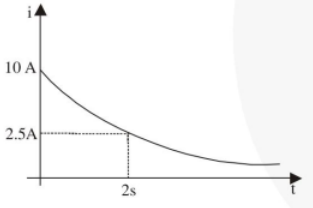


(I) (II) (III)

(A) 18, 8/9, 4 (B) 18, 4, 8/9

(C) 4, 8/9, 18 (D) 8/9, 18, 4

Q9. The figure shows, graph of the current of a discharging circuit of a capacitor through a resistor of resistance 10Ω:



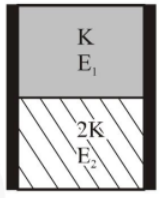
(A) The initial potential difference across the capacitor is 100 volt.

(B) The capacitance of the capacitor is $\frac{1}{10\ell n2}$ F.

(C) The total heat produced in the circuit will be $\frac{500}{\ell n2}$ joules

(D) The thermal power in the resistor will decreases with a time constant $\frac{1}{2\ell n2}$ second.

Q10. A parallel plate capacitor is connected from a cell and then isolated from it. Two dielectric slabs of dielectric constant K and 2K are now introduce in the region between upper half and lower half of the plate (as shown in figure). The electric field intensity in upper half of dielectric is E_1 and lower half is E_2 then -



(A) $E_1 = 2E_2$

(B) Electrostatic potential energy of upper half is less than that of lower half

(C) Induced charges on both slabs are same

(D) Charge distribution on the plates remains same after insertion of dielectric.

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q11. Two uniformly charged spherical drops at potential V coalapse to form a larger drop. If capacity of each smaller drop is C then find capacity and potential of larger drop.

Q12. A cylindrical capacitor has two co-axial cylinders of length 15 cm and radii 1.5 cm and 1.4 cm. The outer cylinder is earthed and the inner cylinder is given a charge of 3.5 µC. Determine the capacitance of the system and the potential of the inner cylinder.

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	B	C	B	B	A	A	B	D	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	B	B	A	A	B	A	D	A	D
21	**22**	**23**	**24**	**25**					
C	A	C	B	B					

Ex-1A

1. A,B,C **2.** A,B,C,D **3.** C **4.** A,B,D **5.** A,B,C,D

6. C **7.** B,C,D **8.** B,D **9.** A, C **10.** D

11. A **12.** C **13.** A **14.** D **15.** 10 μF

16. 2/5 **17.** 6μF. **18.** 2.2 **19.** $\frac{9}{25}$ **20.** 8.4×10^{-6} C.

21. $C_2 = 4C_1$ **22.** $C_{eq} = \frac{3}{4}C$ **23.** $= \frac{3}{2}CV^2$

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	A	B	C	C	A	B	C	A	B
11	**12**	**13**	**14**	**15**					
D	D	A	D	B					

Ex-2A

1. B **2.** A **3.** B,C,D **4.** A **5.** A

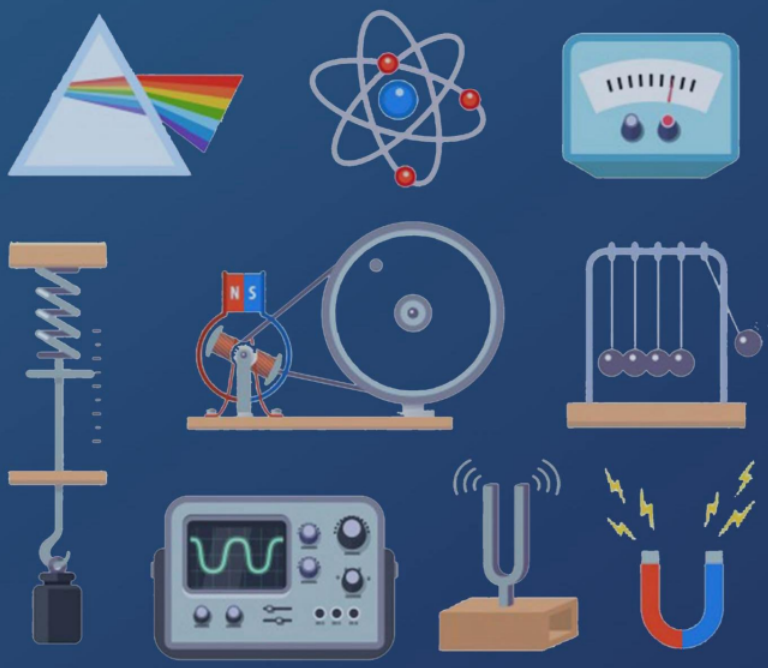
6. C **7.** B **8.** D **9.** A,B,C,D **10.** B

11. $2^{2/3}$ V **12.** 2.89×10^4 V

-: Important Notes & Formulas :-

PHYSICS

Center of Mass



SHEET

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Note

Detailed solutions are available on the eSaral App.

Module Description

For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Locating centre of mass -Discrete Bodies		19,20		
2	Locating centre of mass -Continuous Bodies	1-4	21	1-3	25-27
3	Motion of Centre of mass	5-11	7,18,22	4-9	1
4	Linear Momentum	12-16			
5	Linear momentum Conservation - Part 1	17-21	1	10	14-17
6	Linear momentum Conservation - Part 2	22,23	8	11-13	2,9,18-20, 24,28
7	Impulse	24-28		14,15	
8	Head on collision - Part 1	29,30	9,10,13, 14,23	16,17	3,10
9	Head on collision - Part 2	31,32	2,11,12	18-21	4-6,29
10	Oblique collision			22-27	7,30
11	Centre of mass Frame			28	11
12	Variable mass	33			21-23
13	COM - How things are derived	34,35			
14	After Full Chapter	36,37	3-6, 15-17,24		8,12,13, 31-34

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Locating centre of mass -Continuous Bodies

Q1. The centre of mass of a body .....

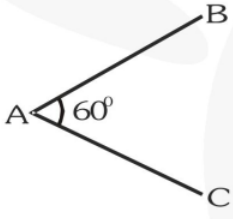
(A) Lies always outside the body.

(B) May lie within, outside or on the surface of the body.

(C) Lies always inside the body.

(D) Lies always on the surface of the body.

Q2. A uniform wire of length ℓ is bent into the shape of 'V' as shown. The distance of its centre of mass from the vertex A is :-



(A) $\ell/2$ (B) $\frac{\ell\sqrt{3}}{4}$

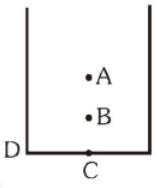
(C) $\frac{\ell\sqrt{3}}{8}$ (D) None of these

Q3. The centre of mass of a non uniform rod of length L whose mass per unit length varies as $\lambda = kx^2/L$ (where k is a constant and x is the distance measured from one end) is at the following distance from the same end :-

(A) 3L/4 (B) L/4

(C) 2L/3 (D) L/3

Q4. A thick uniform wire is bent into the shape of the letter "U" as shown. Which point indicates the location of the center of mass of this wire? A is the midpoint of the line joining mid points of two parallel sides of 'U' shaped wire.

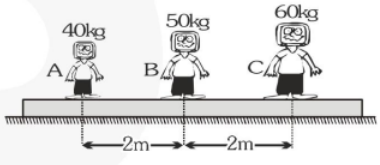


(A) D (B) A

(C) B (D) C

Motion of Centre of mass

Q5. Three man A, B & C of mass 40 kg, 50 kg & 60 kg are standing on a plank of mass 90 kg, which is kept on a smooth horizontal plane. If A & C exchange their positions then mass B will shift :-



(A) 1/3 m towards left

(B) 1/3m towards right

(C) will not move w.r.t. ground

(D) 5/3 m towards left

Q6. An isolated particle of mass m is moving in horizontal plane (x–y), along the x–axis, at $y = 0$. It suddenly explodes into two fragment of masses $\frac{m}{4}$ and $\frac{3m}{4}$. An instant later, the smaller fragment is at $y = +15$ cm. The larger fragment at this instant is at :-

(A) $y = -5$ cm (B) $y = +20$ cm

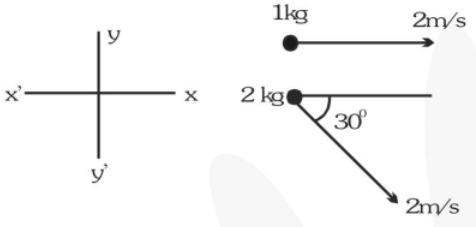
(C) $y = +5$ cm (D) $y = -20$ cm

Q7. Two particles A and B initially at rest, move towards each other under the mutual force of attraction. At the instant when the speed of A is v and the speed of B is 2v, the speed of the centre of mass of the system is :-

(A) 3v (B) v

(C) 1.5v (D) zero

Q8. The velocity of centre of mass of the system as shown in the figure :-



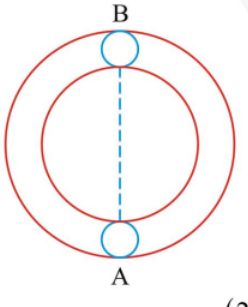
(A) $\left(\frac{2-2\sqrt{3}}{3}\right)\hat{i}-\frac{1}{3}\hat{j}$

(B) $\left(\frac{2+2\sqrt{3}}{3}\right)\hat{i}-\frac{2}{3}\hat{j}$

(C) $4\hat{i}$

(D) None of these

Q9. Two equal spheres A and B lie on a smooth horizontal circular groove at opposite ends of a diameter. At time t =0, A is projected along the groove and it first impinges on B at time t =T_1 and again at timet = T_2. If e is the coefficient of restitution the ratio T_2/T_1 is



(A) $\frac{2}{e}$ (B) $\frac{(2+e)}{2}$

(C) $\frac{2(e+1)}{e}$ (D) $\frac{(2+e)}{e}$

Q10. Sachin (55 kg) and Kapil (65 kg) are sitting at the two ends of a boat at rest in still water. The boat weighs 100 kg and is 3.0 m along. Sachin walks down to Kapil and shakes hand. The boat gets displaced by :-

(A) zero m (B) 0.75 m

(C) 3.0 m (D) 2.3 m

Q11. The velocity of centre of mass in absence of external force is :-

(A) constant (B) zero

(C) increases (D) decreases

Linear Momentum

Q12. Two bodies with masses M_1 and M_2 have equal kinetic energies. If P_1 and P_2 are their respective momenta, then P_1/P_2 is equal to ?

(A) $M_1 : M_2$ (B) $M_1^2 : M_2^2$

(C) $M_2 : M_1$ (D) $\sqrt{M_1} : \sqrt{M_2}$

Q13. A cricket ball of mass 150 gm has an initial velocity $\vec{u} = (3\hat{i}+4\hat{j})$ m / s and a final velocity $\vec{v} = -(3\hat{i}+4\hat{j})$ m / s after being hit. Find the change in momentum (in kg m/s) :-

(A) Zero

(B) $-(0.45\hat{i}+0.6\hat{j})$

(C) $-(0.9\hat{i}+1.2\hat{j})$

(D) $-5(\hat{i}+\hat{j})$

Q14. The velocity of a body of mass 2 kg as a function of t is given by $v(t) = 2t\,\hat{i}+t^2\hat{j}$. Find the momentum at time t = 2 sec.

(A) $(8\,\hat{i}+8\hat{j})$ kg m / s

(B) $2(4\,\hat{i}+4\hat{j})$ kg m / s

(C) $2[2(2)\,\hat{i}+(2)^2\hat{j}]$ kg m / s

(D) All of the above

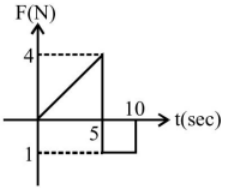
Q15. A force time graph for the motion of a body is shown. The change in momentum of the body between zero and 10 sec is :-

(A) 15 kgm/sec

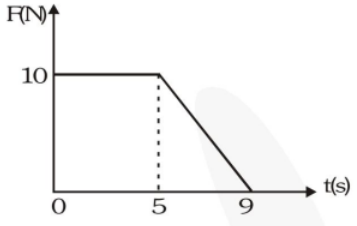
(B) 4 kgm/sec

(C) 6 kgm/sec

(D) 5 kgm/sec



Q16. A body of mass 4 kg is acted on by a force which varies as shown in the graph below. The momentum acquired is -



(A) 280 N–s (B) 140 N–s

(C) 70 N–s (D) 210 N–s

Linear momentum Conservation - Part 1

Q17. A bomb of 12 kg explodes into two pieces of masses 4 kg and 8 kg. The velocity of 8 kg mass is 6 m/sec. The kinetic energy of the other mass is :-

(A) 48 J (B) 32 J

(C) 24 J (D) 288 J

Q18. Two particles A and B start moving due to their mutual interaction only. If at any time 't', $\vec{a}_A$ and $\vec{a}_B$ are their respective accelerations, $\vec{v}_A$ and $\vec{v}_B$ are their respective velocities, and upto that time W_A and W_B are the work done on A and B respectively by the mutual force, m_A and m_B are their masses respectively, then which of the following is always correct.

(A) $\vec{v}_A + \vec{v}_B = 0$

(B) $m_A\vec{v}_A + m_B\vec{v}_B = 0$

(C) $W_A + W_B = 0$

(D) $\vec{a}_A + \vec{a}_B = 0$

Q19. Two particles A and B initially at rest move towards each other under a mutual force of attraction. At the instant when the speed of A is v and the speed of B is 2v, the speed of centre of mass of the system is :-

(A) Zero (B) v

(C) 1.5v (D) 3v

Q20. A rifle of mass M is initially at rest but free to recoil. It fires a bullet of mass m and muzzle velocity v. After firing, the velocity of the rifle (relative to the ground) is:-

(A) –mv (B) –Mv/m

(C) –mv/M (D) –v

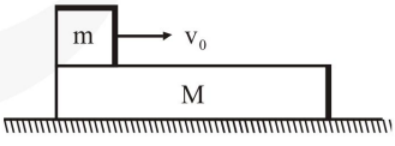
Q21. A gun fires a bullet of mass 50 g with a velocity of 30 $msec^{-1}$. Because of this the gun is pushed back with a velocity of 1 m/sec^{-1}. The mass of the gun is:-

(A) 15 kg (B) 30 kg

(C) 1.5 kg (D) 20 kg

Linear momentum Conservation - Part 2

Q22. The coefficient of friction between the block and plank is μ and ground is smooth. The value of μ is such that block becomes stationary with respect to plank before it reaches the other end. Then which of the following statement is **incorrect.**



(A) The work done by friction on the block is negative.

(B) The work done by friction on the plank is positive .

(C) The net work done by friction is negative.

(D) Net work done by the friction is zero.

Q23. A bomb of mass 3m kg explodes into two pieces of mass m kg and 2m kg. If the velocity of m kg mass is 16 m/s, the total kinetic energy released in the explosion is:-

(A) 192m J (B) 96m J

(C) 384m J (D) 768m J

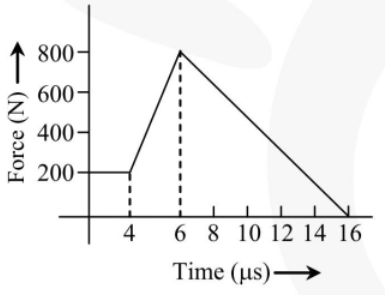
Impulse

Q24. An impulse $\vec{I}$ changes the velocity of a particle from $\vec{v}_1$ to $\vec{v}_2$. Kinetic energy gained by the particle is :-

(A) $\frac{1}{2}\vec{I}\cdot(\vec{v}_1+\vec{v}_2)$ (B) $\frac{1}{2}\vec{I}\cdot(\vec{v}_1-\vec{v}_2)$

(C) $\vec{I}\cdot(\vec{v}_1-\vec{v}_2)$ (D) $\vec{I}\cdot(\vec{v}_1+\vec{v}_2)$

Q25. The magnitude of force (in Newtons) acting on a body varies with time (in micro second) as shown in the figure. The magnitude of total impulse of the force on the body from t = 4 μs to t = 16 μs is -



(A) 5×10^{-2} Ns (B) 5×10^{-3} Ns

(C) 5×10^{-4} Ns (D) 5×10^{-6} Ns

Q26. A ball of mass 1 kg drops vertically on to the floor with a speed of 25 m/s. It rebounds with an initial velocity of 10 m/s. What impulse acts on the ball during contact?

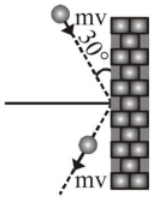
(A) 35kg m/s downwards

(B) 35 kg m/s upwards

(C) 30 kg m/s downwards

(D) 30kg m/s upwards

Q27. An iron ball of mass 100 g having velocity 10 m/s collides with a wall at an angle 30° and rebounds with the same angle. If the period of contact between the ball and wall is 0.1s, then the force experienced by the ball is:-



(A) 100 N (B) 10 N

(C) 0.1 N (D) 1.0 N

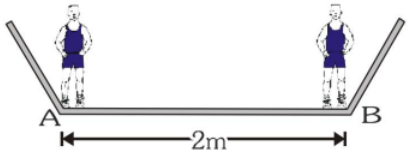
Q28. Two block of masses 10 kg and 4kg are connected by a spring of negligible mass and placed on a frictionless horizontal surface. An impulse gives a velocity of 14m/s to the heavier block in the direction of the lighter block. The velocity of the centre of mass is:-

(A) 30 m/s (B) 20 m/s

(C) 10 m/s (D) 5 m/s

Head on collision - Part 1

Q29. Two persons A and B of weight 80 kg and 50 kg respectively are standing at opposite ends of a boat of mass 70 kg and length 2m at rest. When they interchange their positions then displacement of the centre of mass of the boat will be :-



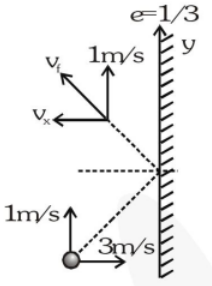
(A) 60 cm towards left

(B) 30 cm towards right

(C) 30 cm towards left

(D) stationary

Q30. A smooth sphere is moving on a horizontal surface with velocity vector $3\hat{i}+\hat{j}$ imme diately before it hits a vertical wall. The wall is parallel to the vector $\hat{j}$ and the coefficient of restitution between the wall and sphere is $\frac{1}{3}$. The velocity vector of the sphere after it hits the wall is :-



(A) $\hat{i}+\hat{j}$ (B) $3\hat{i}-\frac{1}{3}\hat{j}$

(C) $-\hat{i}+\hat{j}$ (D) $\hat{i}-\hat{j}$

Head on collision - Part 2

Q31. A ball hits the floor and rebounds after an inelastic collision. In this case :-

(A) the momentum of the ball just after the collision is the same as that just before the collision

(B) the mechanical energy of the ball remains the same in the collision

(C) the total momentum of the ball and the earth is conserved

(D) the total energy of the ball and the earth is conserved

Q32. A ball of mass 2m impinges directly on a ball of mass m, which is at rest. If the velocity with which the larger ball impinges be equal to the velocity of the smaller mass after impact then the coefficient of restitution :-

(A) $\frac{1}{3}$ (B) $\frac{3}{4}$ (C) $\frac{1}{2}$ (D) $\frac{2}{5}$

Variable mass

Q33. If in a rocket relative velocity v of exhaust gas is constant and mass flow rate is $\frac{dm}{dt}$ then net force on the rocket is :-

(A) $v\frac{dm}{dt}$ (B) $m\frac{dv}{dt}$ (C) 0 (D) ∞

COM - How things are derived

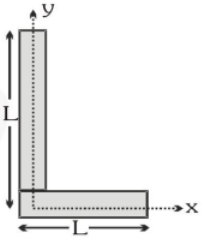
Q34. Centre of mass of two uniform rods of same length but made up of different materials & kept as shown, if the meeting point is the origin of co–ordinates :-

(A) (L/2,L/2)

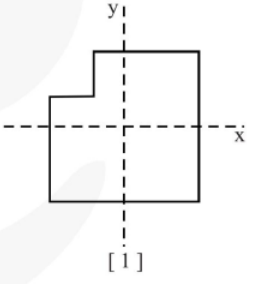
(B) (2L/3,L/2)

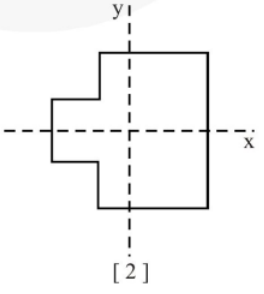
(C) (L/3,L/3)

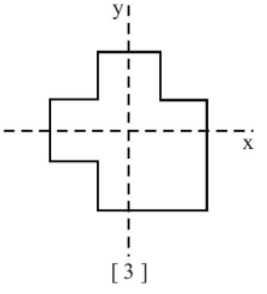
(D) (L/3,L/6)



Q35. A machinist starts with three identical square plates but cuts one corner from one of them, two corners from the second, and three corners from the third. Rank the three plates according to the x-coordinate of their centers of mass, from smallest to largest.





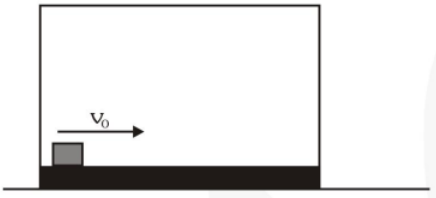


(A) 3, 1, 2 (B) 1, 3, 2

(C) 3, 2, 1 (D) 1 and 3 tie, then 2

After Full Chapter

Q36. As shown, a big box of mass M is resting on a horizontal smooth floor. On the bottom of the box there is a small block of mass m. The block is given an initial speed v_0 relative to the floor, and starts to bounce back and forth between the two walls of the box. Find the final speed of the box when the block has finally come to rest in the box :-



(A) 0 (B) v_0

(C) $\frac{m}{M}v_0$ (D) $\frac{m}{m+M}v_0$

Q37. A body of mass M moves in outer space with velocity v. It is desired to break the body into two parts so that the mass of one part is one–tenth of the total mass. After the explosion, the heavier part comes to rest while the lighter part continues to move in the original direction of motion. The velocity of the small part will be :

(A) v (B) $\left(\frac{v}{2}\right)$

(C) $\left(\frac{v}{10}\right)$ (D) 10 v

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A bag of mass M hangs by a long thread and a bullet (mass m) comes horizontally with velocity v and gets caught in the bag. Then for the combined system (bag + bullet) :-

(A) Momentum is $mMv/(M + m)$

(B) kinetic energy is $(1/2)\,Mv^2$

(C) Momentum is mv

(D) kinetic energy is $m^2v^2/2(M + m)$

Q2. The Fig. shows a string of equally placed beads of mass m, separated by distance d. The beads are free to slide without friction on a thin wire. A constant force F acts on the first bead initially at rest till it makes collision with the second bead. The second bead then collides with the third and so on. Suppose that all collisions are elastic :

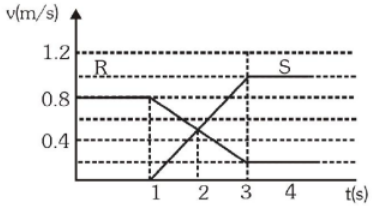
(A) Speed of the first bead immediately before and immediately after its collision with the second bead is $\sqrt{\frac{2Fd}{m}}$ and zero respectively.

(B) Speed of the first bead immediately before and immediately after its collision with the second bead is $\sqrt{\frac{2Fd}{m}}$ and $\frac{1}{2}\sqrt{\frac{2Fd}{m}}$ respectively.

(C) Speed of the second bead immediately after its collision with third bead is zero.

(D) The average speed of the first bead is $\frac{1}{2}\sqrt{\frac{2Fd}{m}}$.

Q3. The diagram shows the velocity–time graph for two masses R and S that collided elastically. Which of the following statements is true ?



I. R and S moved in the same direction after the collision

II. The velocities of R and S were equal at the mid time of the collision.

III. The mass of R was greater than mass of S.

(A) I only (B) II only

(C) I and II only (D) I, II and III

Q4. Two charges moving under their only own mutual attraction separated by large distance initially. Then choose the correct statement (s) :

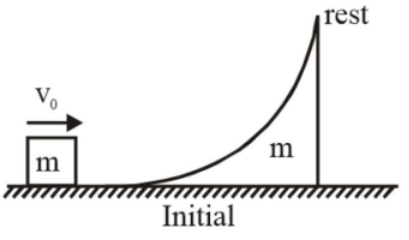
(A) If both are free, mechanical energy is conserved.

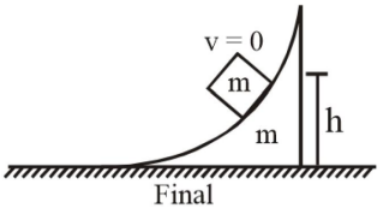
(B) If one is fixed and other is free, mechanical energy is conserved.

(C) If one is fixed and other is free, momentum is conserved.

(D) If both are free momentum is conserved.

Q5. In the arrangement shown, horizontal surface is smooth, but friction is present between the block and the surface of the wedge. Block is given velocity v_0 at $t = 0$. After achieving height 'h' on the wedge, block comes to rest with respect to wedge at $t = t_0$. Then from $t = 0$ to $t = t_0$:-





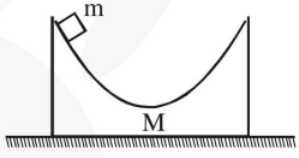
(A) Work done by friction on the block is negative

(B) Work done by friction on the wedge is negative

(C) Work done by block on the wedge is positive

(D) Work done by wedge on the block is positive

Q6. Figure shows a wedge on which a small block is released from rest. All the surfaces are smooth system comprises of wedge and blocks. Mark the correct statement(s) regarding motion of block on wedge till block attains maximum height on wedge.



(A) Acceleration of centre of mass of system is initially vertically down then vertically up.

(B) Initially centre of mass moves down and then up.

(C) At the maximum height block and wedge move with common velocity.

(D) Centre of mass of wedge moves towards left then right

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q7. A particle of mass 1kg has velocity $\vec{v}_1 = (2t)\hat{i}$ and another particle of mass 2 kg has velocity $\vec{v}_2 = (t^2)\hat{j}$.

Column I	Column II
(A) Net force on centre of mass at 2 s	(P) $\frac{20}{9}$ unit
(B) Velocity of centre of mass at 2s	(Q) $\sqrt{68}$ unit
(C) Displacement of centre of mass in 2s	(R) $\frac{\sqrt{80}}{3}$ unit
	(S) None

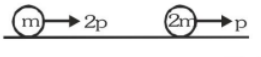
Q8. If net force on a system of particles is zero, then

Column I	Column II
(A) Acceleration of centre of mass	(P) Constant
(B) Velocity of centre of mass	(Q) Zero
(C) Momentum of centre of mass	(R) May be zero
(D) Velocity of an individual particle of the system	(S) May be constant

Q9. A particle of mass m, kinetic energy K and momentum p collides head on elastically with another particle of mass 2 m at rest. After collision :

Column I	Column II
(A) Momentum of first particle	(P) 3/4 p
(B) Momentum of second particle	(Q) – K/9
(C) Kinetic energy of first particle	(R) – p/3
(D) Kinetic energy of second particle	(S) $\frac{8K}{9}$
	(T) None

Q10. Two balls of mass m and 2m each have momentum 2p and p in the direction shown in figure. During collision they exert an impulse of magnitude p on each other.

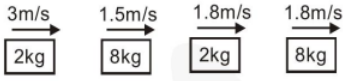
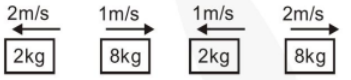
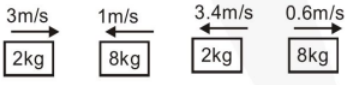


Column I	Column II
(A) After collision momentum of m	(P) 2p
(B) After collision momentum of 2m	(Q) p
(C) Coefficient of restitution between them	(R) 1
	(S) None

Q11.

Column I	Column II
(A) Elastic collision	(P) KE is conserved
(B) Inelastic collision	(Q) KE after collision = KE before collision
(C) Perfectly inelastic collision	(R) KE after collision ≠ KE before collision
	(S) Particles stick after collision
	(T) Linear momentum is conserved
	(U) Relative velocity of separation after collision is zero

Q12. In Column-I, 4 situations are depicted and in column-II, 4 possible kinds of collision are listed. Match the situation with type of collision.

Column-I (Before)	Column-II (After)
(A) 	(P) Elastic
(B) 	(Q) Perfectly Inelastic
(C) 	(R) Partially elastic
	(S) Collision is not possible

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

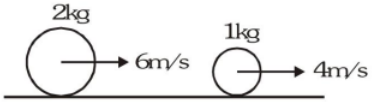
Paragraph # 1 (Ques. 13 to 14)

When two bodies collide normally they exert equal and opposite impulses on each other.

Impulse = change in linear momentum. Coefficient of restitution between two bodies is given by :-

$$e = \frac{|\text{Relative velocity of separation}|}{|\text{Relative velocity of approach}|} = 1,$$

for elastic collision



Two bodies collide as shown in figure. During collision they exert impulse of magnitude J on each other.

Q13. If the collision is elastic, the value of J is ..... N–s :-

(A) 10/3 (B) 5/4

(C) 8/3 (D) 3/2

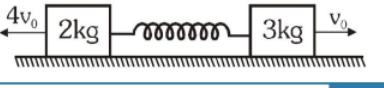
Q14. For what values of J (in N–s) the 2 kg block will change its direction of velocity :-

(A) $J < 12$ (B) $J > 12$

(C) $J < 10$ (D) $J > 10$

Paragraph # 2 (Ques. 15 to 17)

2 kg and 3 kg blocks are placed on a smooth horizontal surface and connected by spring which is unstretched initially. The blocks are imparted velocities as shown in the figure.



Q15. The maximum energy stored in the spring in the subsequent motion will be

(A) $5v_0^2$ (B) $15v_0^2$

(C) zero (D) $10v_0^2$

Q16. Maximum speed of 3 kg block in the subsequent motion will be

(A) v_0 (B) $2v_0$

(C) $3v_0$ (D) $4v_0$

Q17. Maximum speed of 2 kg block in the subsequent motion will be

(A) v_0 (B) $2v_0$

(C) $3v_0$ (D) $4v_0$

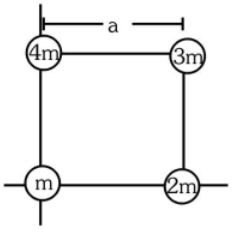
NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q18. The figure shows the positions and velocities of two particles. If the particles move under the mutual attraction of each other, then find the position of centre of mass at t = 1 s.

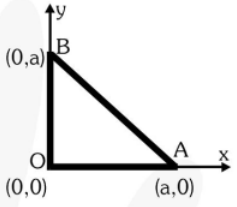
SUBJECTIVE TYPE

Q19. Four particles of masses m, 2m, 3m, 4m are placed at corners of a square of side 'a' as shown in fig. Find out coordinates of centre of mass.

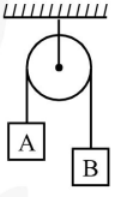


Q20. A rigid body consists of a 3 kg mass connected to a 2 kg mass by a massless rod. The 3kg mass is located at $\vec{r}_1 = (2\hat{i} + 5\hat{j})$ m and the 2 kg mass at $\vec{r}_2 = (4\hat{i} + 2\hat{j})$ m. Find the length of rod and the coordinates of the centre of mass.

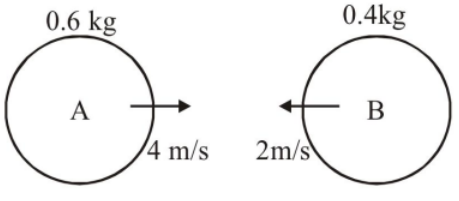
Q21. Three rods of the same mass are placed as shown in the figure. Calculate the coordinates of the centre of mass of the system.



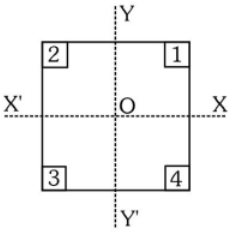
Q22. In the arrangement shown in the figure, $m_A = 2$ kg and $m_B = 1$ kg. String is light and inextensible. Find the acceleration of centre of mass of both the blocks. Neglect friction everywhere.



Q23. The velocities of two steel balls before impact are shown. If after head on impact the velocity of ball B is observed to be 3 m/ s to the right, the coefficient of restitution is-



Q24. Figure shows a uniform square plate from which four identical squares at the corners will be removed.



(i) Where is the centre of mass of the plate originally.

(ii) Where is C.M. after square 1 is removed.

(iii) Where is C.M. after squares 1 and 2 removed.

(iv) Where is C.M. after squares 1 and 3 are removed.

(v) Where is C.M. after squares 1, 2 and 3 are removed.

(vi) Where is C.M. after all the four squares are removed.

Give Answers in terms of quadrants and axes.

Exercise - 2 — *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. A piece of paper (shown in figure1) is in form of a square. Two corners of this square are folded to make it appear like figure.2 . Both corners are put together at centre of square 'O'. If O is taken to be (0,0), the centre of mass of new system will be at :

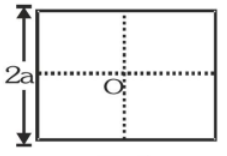


Fig.1

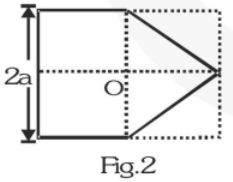
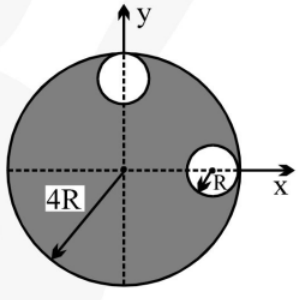


Fig.2

(A) $\left(-\frac{a}{8}, 0\right)$ (B) $\left(-\frac{a}{6}, 0\right)$

(C) $\left(\frac{a}{12}, 0\right)$ (D) $\left(-\frac{a}{12}, 0\right)$

Q2. From the circular disc of radius 4R two small disc of radius R are cut off. The centre of mass of the new structure will be at :



(A) $\frac{R}{5}\hat{i}+\frac{R}{5}\hat{j}$ (B) $-\frac{R}{5}\hat{i}+\frac{R}{5}\hat{j}$

(C) $\frac{-3R}{14}(\hat{i}+\hat{j})$ (D) None of these

Q3. If linear density of a rod of length 3 m varies as $\lambda = 2 + x$, then the position of the centre of gravity of the rod is:-

(A) $\frac{7}{2}$m (B) $\frac{12}{7}$m

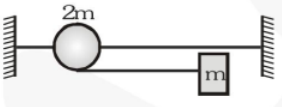
(C) $\frac{10}{7}$m (D) $\frac{9}{7}$m

Q4. Considering a system having two masses m_1 and m_2 in which first mass is pushed towards centre of mass by a distance a, the distance required to be moved for second mass to keep centre of mass at same position is :-

(A) $\frac{m_1}{m_2}a$ (B) $\frac{m_1m_2}{a}$

(C) $\frac{m_2}{m_1}a$ (D) $\left(\frac{m_2m_1}{m_1+m_2}\right)a$

Q5. A bead can slide on a smooth straight wire and a particle of mass m attached to the bead by a light string of length L. The particle is held in contact with the wire and with the string taut and is then let fall. If the bead has mass 2m then when the string makes an angle θ with the wire, the bead will have slipped a distance.



(A) $L(1-\cos\theta)$ (B) $\left(\frac{L}{2}\right)(1-\cos\theta)$

(C) $\left(\frac{L}{3}\right)(1-\cos\theta)$ (D) $\left(\frac{L}{6}\right)(1-\cos\theta)$

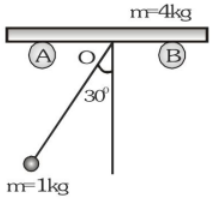
Q6. A ball of mass 1 kg is suspended by an inextensible string 1 m long attached to a point O of a smooth horizontal bar resting on a fixed smooth supports A and B. The ball is released from rest from the position when the string makes an angle of 30° with the vertical. The mass of the bar is 4 kg. The displacement in meters of the bar when the string makes the maximum angle on the other side of the vertical is :-

(A) 0

(B) 0.2

(C) 0.25

(D) 0.5



Q7. An open water tight railway wagon of mass 5 x 10^3 kg coasts at an initial velocity 1.2 m/s without friction on a railway track. Rain drops fall vertically downwards into the wagon. The velocity of the wagon after it has collected 10^3 kg of water will be :-

(A) 0.5 m/s (B) 2m/s

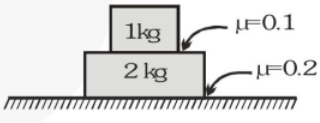
(C) 1 m/s (D) 1.5 m/s

Q8. Three interacting particles of masses 100 g, 200 g and 400 g each have a velocity of 20 m/s magnitude along the positive direction of x-axis, y-axis and z-axis. Due to force of interaction the third particle stops moving. The velocity of the second particle is $\left(10\hat{j}+5\hat{k}\right)$. What is the velocity of the first particle?

(A) $20\hat{i}+20\hat{j}+70\hat{k}$ (B) $10\hat{i}+20\hat{j}+8\hat{k}$

(C) $30\hat{i}+10\hat{j}+7\hat{k}$ (D) $15\hat{i}+5\hat{j}+60\hat{k}$

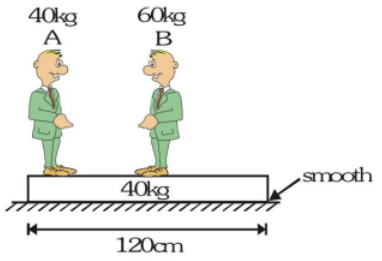
Q9. If both the blocks as shown in the given arrangement are given together a horizontal velocity towards right. If a_{cm} be the subsequent acceleration of the centre of mass of the system of blocks then a_{cm} equals :-



(A) 0 m/s^2 (B) $\frac{5}{3}$ m/s^2

(C) $\frac{7}{3}$ m/s^2 (D) 2 m/s^2

Q10. Two men 'A' and 'B' are standing on a plank. 'B' is at the middle of the plank and 'A' is at the left end of the plank. Lower surface of the plank is smooth. System is initially at rest and masses are as shown in figure. A and B starts moving such that the position of 'B' remains fixed with respect to ground then 'A' meets 'B'. Then the point where A meets B is located at :-



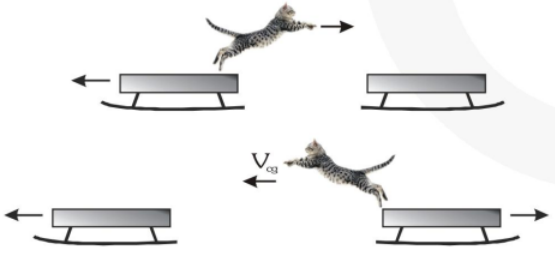
(A) the middle of the plank

(B) 30 cm from the left end of the plank

(C) the right end of the plank

(D) None of these

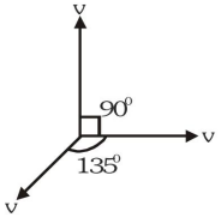
Q11. A strange cat with a mass m_c is sitting at rest on the left sled of a pair of identical sleds. The sleds have mass m_s and sit on frictionless ice. Suddenly, the cat leaps to the right sled, traveling with a horizontal speed v_{cg} measured with respect to the ground. The instant the cat reaches the right sled, it turns around and leaps back to the left sled. The horizontal component of the cat's speed is again v_{cg} measured with respect to the ground. The final speed of right sled in terms of the masses of the cat and sleds and the cat's leaping speed is (The cat remains on the left sled after its return) :-



(A) $\frac{2m_c v_{cg}}{m_s + m_c}$ (B) $\frac{2m_c v_{cg}}{m_s}$

(C) $\frac{m_c v_{cg}}{m_s + m_c}$ (D) $\frac{m_c v_{cg}}{m_s}$

Q12. A particle of mass 4m which is at rest explodes into four equal fragments. All 4 fragments scattered in the same horizontal plane. Three fragments are found to move with velocity v each as shown in the fig. The total energy released in the process of explosion is :-



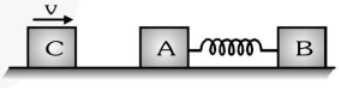
(A) $mv^2(3-\sqrt{2})$

(B) $mv^2(3-\sqrt{2})/2$

(C) $2mv^2$

(D $mv^2(1+\sqrt{2})/2$

Q13. Two blocks A and B each of mass m, are connected by a massless spring of natural length L and spring constant k. The blocks are initially resting on a smooth horizontal floor with the spring at its natural length, as shown in fig. A third identical block C, also of mass m, moves on the floor with a speed v along the line joining A and B, and collides elastically with A. Then :-



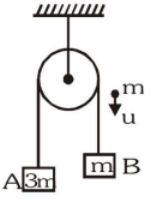
(A) the kinetic energy of the A–B system, at maximum compression of the spring, is zero

(B) the kinetic energy of the A–B system, at maximum compression of the spring, is $\frac{mv^2}{4}$

(C) the maximum compression of the spring is $v\sqrt{\left(\frac{m}{k}\right)}$

(D) the maximum compression of the spring is $2v\sqrt{\frac{m}{2k}}$

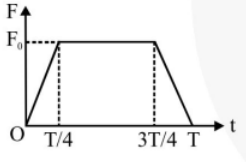
Q14. A system of two blocks A and B are connected by an inextensible massless strings as shown. The pulley is massless and frictionless. Initially the system is at rest when, a bullet of mass 'm' moving with a velocity 'u' as shown hits the block 'B' and gets embedded into it. The impulse imparted by tension force to the block of mass 3m is-



(A) $\frac{5mu}{4}$ (B) $\frac{4mu}{5}$

(C) $\frac{2mu}{5}$ (D) $\frac{3mu}{5}$

Q15. A particle of mass m moving with a velocity u makes an elastic one dimensional collision with a stationary particle of mass m establishing a contact with it for extremely small time T. Their force of contact increases from zero to F_0 linearly in time T/4, remains constant for a further time T/2 and decreases linearly from F_0 to zero in further time T/4 as shown. The magnitude possessed by F_0 is :-



(A) $\frac{mu}{T}$ (B) $\frac{2mu}{T}$

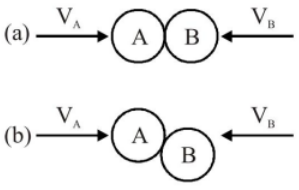
(C) $\frac{4mu}{3T}$ (D) $\frac{3mu}{4T}$

Q16. Two balls of same mass are dropped from the same height h, on to the floor. The first ball bounces to a height h/4 ,after the collision & the second ball to a height h/16. The impulse applied by the first & second ball on the floor are I_1 and I_2 respectively. Then :-

(A) $5I_1 = 6I_2$ (B) $6I_1 = 5I_2$

(C) $I_1 = 2I_2$ (D) $2I_1 = I_2$

Q17. Two bodies, A and B, collide as shown in figures a and b below :



Circle the true statement :

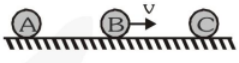
(A) They exert equal and opposite forces on each other in (a) but not in (b)

(B) They exert equal and opposite force on each other in (b) but not in (a)

(C) They exert equal and opposite force on each other in both (a) and (b)

(D) The forces are equal and opposite to each other in (a), but only the components of the forces parallel to the velocities are equal in (b).

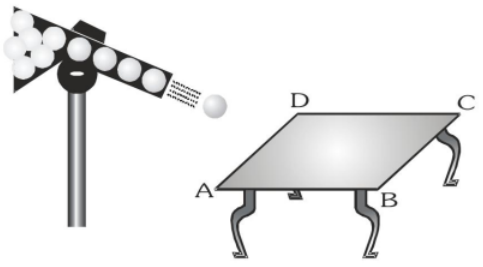
Q18. Three balls A, B and C ($m_A = m_C = 4m_B$) are placed on a smooth horizontal surface. Ball B collides with ball C with an initial velocity v as shown in the figure. Total number of collisions between the balls will be (All collisions are elastic) :-



(A) One (B) Two

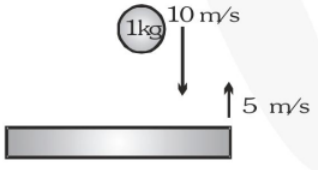
(C) Three (D) Four

Q19. A gun which fires small balls of mass 20 gm is firing 20 balls per second on the smooth horizontal table surface ABCD. If the collision is perfectly elastic and balls are striking at the centre of table with a speed 5 m/s at an angle of 60° with the vertical just before collision, then force exerted by one of the leg on ground is (assume total weight of the table is 0.2 kg and g = 10 m/s²) :-



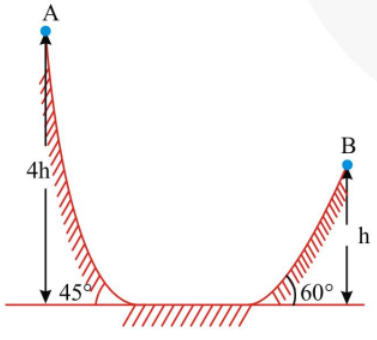
(A) 0.5 N (B) 1 N
(C) 0.25 N (D) 0.75 N

Q20. A ball of mass 1 kg strikes a heavy platform elastically, moving upwards with a velocity of 5m/s. The speed of the ball just before the collision is 10m/s downwards. Then the impulse imparted by the platform on the ball is :-



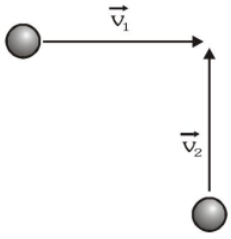
(A) 15 N–s (B) 10 N–s
(C) 20 N–s (D) 30 N–s

Q21. Two identical balls A and B are released from the position shown in Fig. They collide elastically with each other on the horizontal portion. The ratio of heights attained by A and B after collision is(neglect friction).



(A) 1 : 4 (B) 2 : 1
(C) 4 : 13 (D) 2 : 5

Q22. Two balls of masses m_1, m_2 and speeds v_1 and v_2 collide at right angle. The maximum amount of kinetic energy loss due to inelastic collision is ____.



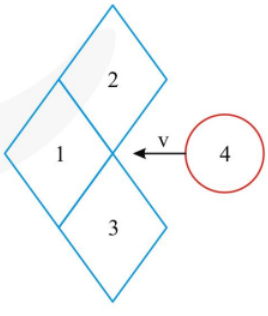
(A) $\frac{1}{2}(m_1v_1^2 + m_2 v_2^2)$

(B) $\frac{1}{2}\frac{m_1m_2}{m_1+m_2}(v_1^2 + v_2^2)$

(C) $\frac{1}{2}\frac{1}{m_1+m_2}(m_1^2v_1^2 + m_2^2v_2^2)$

(D) $\frac{1}{2}\frac{m_1m_2}{m_1+m_2}(v_1+v_2)^2$

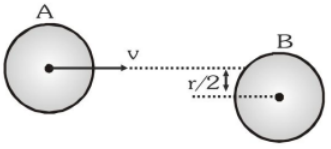
Q23. A smooth washer impinges at a velocity 'v' on a group of three smooth identical blocks resting on a smooth horizontal surface as shown in fig. Mass of each block is equal to mass of the washer. The diameter of the of the washer and its height are equal to edge of the block. The velocity of blocks (2) and (3) after collision is -



(A) v (B) $\frac{v}{\sqrt{2}}$

(C) $\frac{v}{2}$ (D) 2v

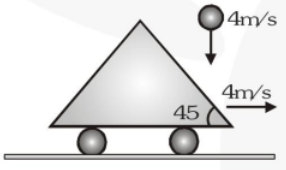
Q24. A disk A of radius r moving on perfectly smooth surface at a speed v undergoes an elastic collision with an identical stationary disk B. Find the velocity of the disk B after collision if the impact parameter is r/2 as shown in the figure :-



(A) $\frac{\sqrt{15}}{4}v$ (B) $\frac{v}{4}$

(C) $\frac{v}{2}$ (D) $\frac{\sqrt{3}v}{2}$

Q25. A small ball falling vertically downward with constant velocity 4m/s strikes elastically a massive inclined cart moving with velocity 4m/s horizontally as shown. The velocity of the rebound of the ball is :-



(A) $4\sqrt{2}$ m/s (B) $4\sqrt{3}$ m/s

(C) 4 m/s (D) $4\sqrt{5}$ m/s

Q26. A spherical ball of mass 1 kg moving with a uniform speed of 1 m/s collides symmetrically with two identical spherical balls of mass 1 kg each at rest touching each other. If the two balls move with 0.5m/s in two directions at the same angle of 60° with the direction of the first ball, the loss of kinetic energy on account of the collision is :-

(A) 0.125 J (B) 0.5J

(C) 1.0 J (D) 0.75J

Q27. A particle moving horizontally collides with a fixed plane inclined at 60° to the horizontal. If it bounces vertically, the coefficient of restitution is :-

(A) $\frac{1}{\sqrt{3}}$ (B) $\frac{2}{\sqrt{3}}$

(C) $\frac{1}{3}$ (D) None of these

Q28. A block of mass 2 kg moving with velocity of 20 m/s collide with a block of mass 2 kg attached with one end of a spring. A block of mass 3 kg is attached to the other end as shown. If the collision is elastic then maximum compression in spring will be (k = 1000 N/m)

(A) $20\sqrt{3}$ cm (B) $40\sqrt{3}$ cm

(C) $60\sqrt{3}$ cm (D) None

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A non–zero external force acts on a system of particles. The velocity and acceleration of the centre of mass are found to be v_0 and a_C respectively at any instant t. It is possible that :

(i) $v_0=0$, $a_C=0$

(ii) $v_0 \neq 0$, $a_C=0$

(iii) $v_0= 0$, $a_C\neq0$

(iv) $v_0\neq 0$, $a_C\neq0$

Then -

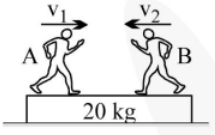
(A) (iii) and (iv) are true.

(B) (i) and (ii) are true.

(C) (i) and (iii) are true.

(D) (ii), (iii) and (iv) are true.

Q2. In the figure shown the system is at rest initially. Two persons 'A' and 'B' of masses 40 kg each move with speeds v_1 and v_2 respectively towards each other on a plank lying on a smooth horizontal surface as shown in figure. Plank travels a distance of 20 m towards right direction in 5 sec. (Here v_1 and v_2 are given with respect to the plank). Then the possible condition(s) can be -



(A) $v_1 = 0$ m/s, $v_2 = 10$ m/s

(B) $v_1 = 5$ m/s, $v_2 = 15$ m/s

(C) $v_1 = 10$ m/s, $v_2 = 20$ m/s

(D) $v_1 = 2$ m/s, $v_2 = 12$ m/s

Q3. Two balls A and B having masses 1 kg and 2 kg, moving with speeds 21 m/s and 4 m/s respectively in opposite direction, collide head on. After collision A moves with a speed of 1 m/s in the same direction, then correct statements is :

(A) The velocity of B after collision is 6 m/s opposite to its direction of motion before collision.

(B) The coefficient of restitution is 0.2.

(C) The loss of kinetic energy due to collision is 200 J.

(D) The impulse of the force between the two balls is 40 N–S.

Q4. A set of n–identical cubical blocks lies at rest parallel to each other along a line on a smooth horizontal surface. The separation between the near surfaces of any two adjacent blocks is L. The block at one end is given a speed v towards the next one at time t = 0. All collisions are completely inelastic, then :-

(A) The last block starts moving at

$$t = n\,(n-1)\frac{L}{2v}$$

(B) The last block starts moving at

$$t = (n-1)\frac{L}{v}$$

(C) The centre of mass of the system will have a final speed $\frac{v}{n}$

(D) The centre of mass of the system will have a final speed v.

Q5. A particle moving with kinetic energy = 3 joule makes an elastic head on collision with a stationary particle which has twice its mass during the impact.

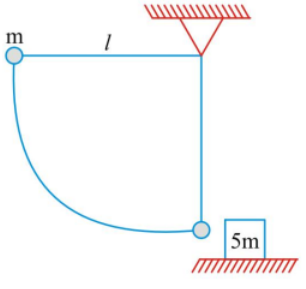
(A) The minimum kinetic energy of the system is 1 joule.

(B) The maximum elastic potential energy of the system is 2 joule.

(C) Momentum and total energy of the system are conserved at every instant.

(D) The ratio of kinetic energy to potential energy of the system first decreases and then increases.

Q6. A pendulum bob of mass m connected to the end of an ideal string of length l is released from rest from horizontal position as shown in Fig. At the lowest point, the bob makes an elastic collision with a stationary block of mass 5m, which is kept on a frictionless surface. Mark out the correct statement(s) for the instant just after the impact.



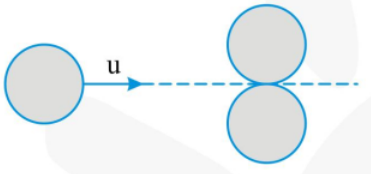
(A) Tension in the string at lowest point just after collision is (17/9) mg.

(B) Tension in the string at lowest point just before collision is 3mg.

(C) The velocity of the block just after collision is $\sqrt{2gl}/3$.

(D) The maximum height attained by the pendulum bob after impact is (measured from the lowest position) $\frac{4l}{9}$.

Q7. Two equal spheres of mass *m* are in contact on a smooth horizontal table. A third identical sphere impinges symmetrically on them and reduces to rest then :



(A) Coefficient of restitution is $e = \frac{2}{3}$

(B) Loss of kinetic energy $\frac{1}{6}mu^2$ where u is velocity before impact

(C) After the collision, velocity of equal mass sphere is $\frac{u}{\sqrt{3}}$

(D) Loss of kinetic energy $\frac{1}{3}mu^2$

Q8. In a one dimensional collision between two identical particles A and B, B is stationary and A has momentum p before impact. During impact, B gives impulse J to A.

(A) The total momentum of the 'A plus B' system is p before and after the impact, and (p-J) during the impact.

(B) During the impact A gives impulse of magnitude J to B.

(C) The coefficient of restitution is $\frac{2J}{p} - 1$.

(D) The coefficient of restitution is $\frac{J}{p} + 1$.

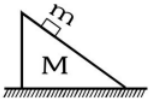
MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q9. In each situation of column–I, a system involving two bodies is given. All strings and pulleys are light and friction is absent everywhere. Initially each body of every system is at rest. Consider the system in all situation of column I from rest till any collision occurs. Then match the statements in column – I with the corresponding results in column–II.

Column I

(A) The block plus wedge system is placed over smooth horizontal surface. After the system is released from rest, the centre of mass of system

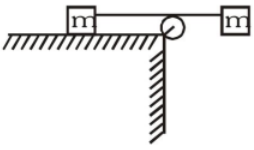


Column II

(P) Shifts towards right

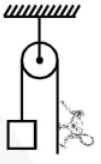
(B) The string connecting both the blocks of mass m is horizontal. Left block is placed over smooth horizontal table as shown. After the two block system is released from rest, the centre of mass of system

(Q) Shifts downwards



(C) The block and monkey have same mass. The monkey starts climbing up the rope. After the monkey starts climbing up, the centre of mass of monkey+block system

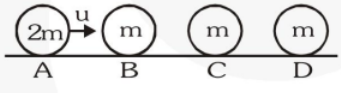
(R) Shifts upwards



(D) Both block of mass m are initially at rest. The left block is given initial velocity u downwards. Then, the centre of mass of two block system afterwards

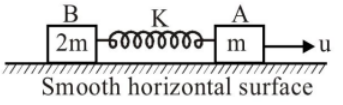
(S) Does not shift

Q10. Four balls A,B,C and D are kept on a smooth horizontal surface as shown in figure. Ball A is given velocity u towards B- (Assume each collision to be elastic)



Column-I	**Column-II**
(A) Total impulse of all collisions on A	(P) $\frac{4mu}{9}$
(B) Total impulse of all collisions on B	(Q) $\frac{4mu}{27}$
(C) Total impulse of all collision on C	(R) $\frac{4mu}{3}$
(D) Total impulse of all collisions on D	(S) $\frac{52}{27}mu$

Q11. Two blocks A and B of mass m and 2m respectively are connected by a massless spring of spring constant K. This system lies over a smooth horizontal surface. At t = 0 the block A has velocity u towards right as shown while the speed of block B is zero, and the length of spring is equal to its natural length at that instant.

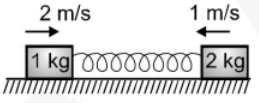


Column-I	Column-II
(A) The velocity of block A	(P) can never be zero
(B) The velocity of block B	(Q) may be zero at certain instants of time
(C) The kinetic energy of system of two block	(R) is minimum at maximum compression of spring
(D) The potential energy of spring	(S) is maximum at maximum extension of spring

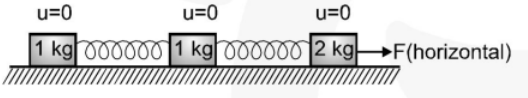
Q12. In all cases in **column–I**, the blocks/plank/trolley are placed on the smooth horizontal surface.

Column–I

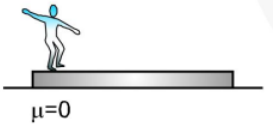
(A) The initial velocities given to the blocks when spring is relaxed are as shown



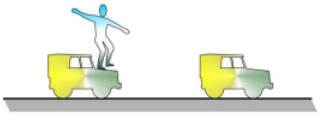
(B) A constant force is applied on 2 kg block. Springs are initially relaxed



(C) Initially system is at rest. Man starts be moving on a large plank with constant velocity.



(D) A man standing on one of the trolleys (initially at rest) jumps to the other with relative velocity of 4 m/s horizontally



Column–II

(P) Centre of mass of the complete system shown will not move horizontally

(Q) Centre of mass of the complete system shown will move horizontally

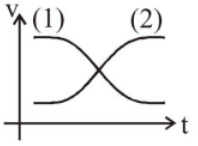
(R) Mechanical energy of the system will be conserved

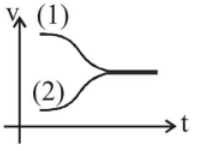
(S) Mechanical energy of the system will increase

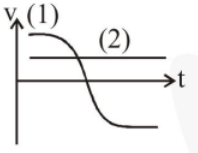
(T) Linear momentum of the complete system will always remain constant

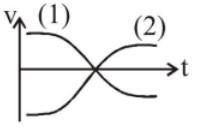
Q13. Assume that 2 bodies collide head on. The graph of their velocities with time are shown in column-I match them with appropriate situation in column-II

Column-I

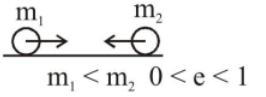
(A) 

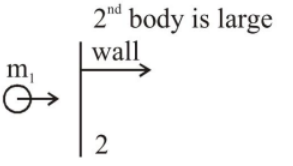
(B) 

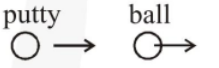
(C) 

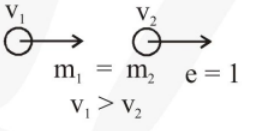
(D) 

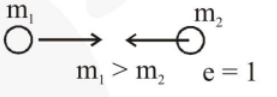
Column-II

(P) 

(Q) 

(R) 

(S) 

(T) 

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph # 1 (Ques. 14 to 17)

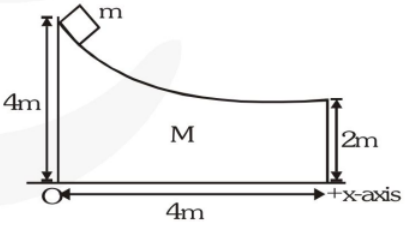
If net force on a system in a particular direction is zero (say in horizontal direction) we can apply:

$$\Sigma m_R x_R = \Sigma m_L x_L,$$

$$\Sigma m_R v_R = \Sigma m_L v_L$$

and $$\Sigma m_R a_R = \Sigma m_L a_L$$

Here R stands for the masses which are moving towards right and L for the masses towards left, x is displacement, v is velocity and a the acceleration (all with respect to ground). A small block of mass m = 1 kg is placed over a wedge of mass M = 4 kg as shown in figure. Mass m is released from rest. All surfaces are smooth. Origin O is as shown.



Q14. Final velocity of the wedge is ..... m/s :-

(A) $\sqrt{3}$ (B) $\sqrt{2}$

(C) $\frac{1}{\sqrt{2}}$ (D) $\frac{1}{\sqrt{3}}$

Q15. The block will strike the x–axis at x = ...m :-

(A) 4.2 (B) 7.6

(C) 5.6 (D) 6.8

Q16. Normal reaction between the two blocks at an instant when absolute acceleration of m is $5\sqrt{3}\ m/s^2$ at 60° with horizontal is ..... N. Normal reaction at this instant is making 30° with horizontal :-

(A) 6 (B) 10

(C) 4 (D) 5

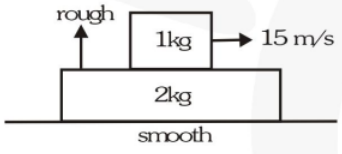
Q17. At the same instant reaction on the wedge from the ground is ..... N.

(A) 42.5 (B) 40

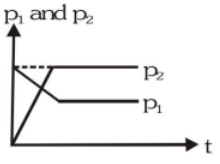
(C) 43.46 (D) None of these

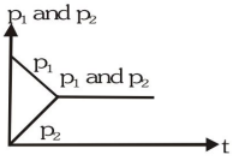
Paragraph # 2 (Ques. 18 to 20)

A 1 kg block is given a velocity of 15 m/s towards right over a very long rough plank of mass 2 kg as shown in figure.



Q18. The correct graph showing linear momentum of 1 kg (i.e. p_1) and of 2kg (i.e. p_2) versus time is :-

(A)


(B)


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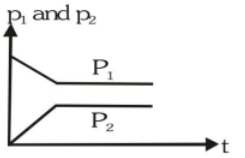

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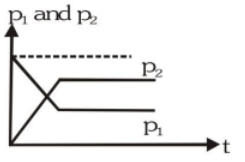


Q19. If coefficient of friction between the two blocks is equal to 0.4, then magnitude of initial slope of p_1 versus t and p_2 versus t (in SI unit) will be :-

(A) 4 and 2 (B) 2 and 4

(C) 4 and 4 (D) 2 and 2

Q20. Momentum of both the blocks are equal at time t = ...seconds :-

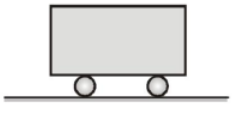
(A) 1.75 (B) 1.875

(C) 2.5 (D) 1.25

Paragraph # 3 (Ques. 21 to 23)

When the mass of a system is variable, a thrust force has to be applied on it in addition to all other forces acting on it. This thrust force is given by :

$\vec{F} = \vec{v}_r\left(\pm\frac{dm}{dt}\right)$. Here $\vec{v}_r$ is the relative velocity with which the mass dm either enters or leaves the system. A car has total mass 50 kg. Gases are ejected from this backwards with relative velocity 20 m/s. The rate of ejection of gas is 2 kg/s.Total mass of gas is 20 kg. Coefficient of friction between the car and road is $\mu = 0.1$.



Q21. Car will start moving after time t = ... second :-

(A) 4 (B) 10

(C) 5 (D) 8

Q22. Maximum speed of car will be v = ... m/s :- (Take $\ell n \frac{4}{3} = 0.28$)

(A) 0.6 (B) 0.8 (C) 1.0 (D) 1.2

Q23. Car will stop after (from starting) t = ... seconds :-

(A) 12.2 (B) 6.4 (C) 10.6 (D) 5.8

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

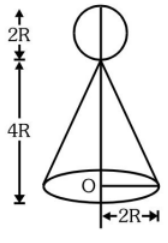
Q24. A plank P and block Q are arranged as shown on a smooth table top. They are given velocities 3 m/s and 6 m/s respectively.

The length of plank is 1m and block is of negligible size. After some time when the block has reached the other end of plank it stops slipping on plank. Find the coefficient of friction between plank P and block Q if mass of plank is double of block.

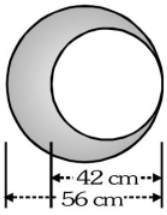
SUBJECTIVE TYPE

Q25. A man has constructed a toy as shown in fig. If density of the material of the sphere is 12 times of the cone compute the position of the centre of mass.

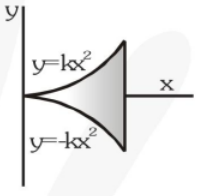
[Centre of mass of a cone of height h is at height of $\frac{h}{4}$ from its base.]



Q26. A circular plate of uniform thickness has a diameter of 56 cm. A circular portion of diameter 42 cm is removed from one edge of the plate as shown in figure. Find the position of the centre of mass of the remaining portion.



Q27. A thin sheet of metal of uniform thickness is cut into the shape bounded by the line x = a and $y = \pm kx^2$, as shown. Find the coefficient of the centre of mass.



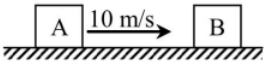
Q28. A spaceship is moving with constant speed v_0 in gravity free space along +Y-axis suddenly shoots out one third of its part with speed $2v_0$ along + X-axis. Find the speed of the remaining part.

Q29. A ball is projected with a velocity u at an angle of elevation α from a point distance d from a smooth vertical wall in a plane perpendicular to it. After rebounding from the wall, it returns to the point of projection.

Prove that $u^2 \sin 2\alpha = gd\left(1+\frac{1}{e}\right)$, where e is coefficient of restitution. Hence find the maximum distance d for which the ball can return to point of projection.

Q30. A sphere of mass m is moving with a velocity $4\hat{i}-\hat{j}$ when it hits a smooth wall and rebounds with velocity $\hat{i}+3\hat{j}$. Find the impulse it receives. Find also the coefficient of restitution between the sphere and the wall.

Q31. The blocks shown in figure have equal masses. The surface of A is smooth but that of B has a friction coefficient of 0.10 with the floor. Block A is moving at a speed of 10m/s towards B which is kept at rest. Find the distance travelled by B if (a) the collision is perfectly elastic and (b) the collision is perfectly inelastic. Take g = 10 m/s^2.



Q32. Two cars initially at rest are free to move in the x direction. Car A has mass 4 kg and car B has mass 2 kg. They are tied together, compressing a spring in between them. When the spring holding them together is burned, car A moves off with a speed of 2 m/s.

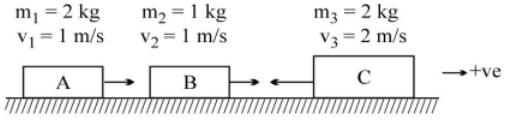
(i) With what speed does car B leave.

(ii) How much energy was stored in the spring before it was burned.

Q33. Three carts move on a frictionless track with inertias and velocities as shown. The carts collide and stick together after successive collisions.

(i) Find loss of mechanical energy when B & C stick together.

(ii) Find magnitude of impulse experienced by A when it sticks to combined mass (B & C).



Q34. A body is thrown vertically upwards from ground with a speed of 10 m/s. If coefficient of restitution of ground, e = 1/2. Find

(i) The total distance travelled by the time it almost stops.

(ii) Time elapsed (after the ball has been thrown) when it is at its subsequent maximum height for the third time.

Answer Key

Ex-1

1	2	3	4	5	6	7	8	9	10
B	C	A	C	B	A	D	B	D	B
11	12	13	14	15	16	17	18	19	20
A	D	C	D	D	C	D	B	A	C
21	22	23	24	25	26	27	28	29	30
C	D	A	A	B	B	B	C	C	C
31	32	33	34	35	36	37			
C	C	A	D	B	D	D			

Ex-1A

1. C,D **2.** A,C **3.** D **4.** A, B,D **5.** A, C

6. B, C

7. (A) → Q; (B) → R; (C) → P

8. (A) → Q, (B) → P,R; (C) → P,R; (D) → R,S

9. (A) → R; (B) → T; (C) → T; (D) → S

10. (A) → Q; (B) → P; (C) → S

11. (A) → Q,T; (B) → R,T; (C) → R,S,T,U **12.** (A)-Q (B)-S (C)-P

13. C **14.** B **15.** B **16.** C **17.** D

18. x = 6m **19.** $\left(\frac{a}{2},\frac{7a}{10}\right)$ **20.** $\sqrt{13}$ m, $\left(\frac{14}{5},\frac{19}{5}\right)$ **21.** $\left(\frac{a}{3},\frac{a}{3}\right)$

22. g/9 downwards **23.** $\frac{7}{18}$

24. **(i)** at O **(ii)** Diagonally from O to 3 **(iii)** Along OY'
(iv) at O **(v)** Diagonally from O to 4 **(vi)** at O

Ex-2

1	2	3	4	5	6	7	8	9	10
D	C	B	A	C	B	C	A	D	C
11	12	13	14	15	16	17	18	19	20
B	A	B	D	C	A	C	B	B	D
21	22	23	24	25	26	27	28		
C	B	B	A	D	A	C	B		

Ex-2A

1. A **2.** A,B,C,D **3.** A,B,C **4.** A,C **5.** A,B,C,D

6. A,B,C,D **7.** A,B,C **8.** B,C

9. (A)-Q; (B)-P, Q; (C)-R; (D) S

10. A-(S), B-(Q), C-(P), D-(R)

11. (A)-Q; (B)-Q; (C)-P,R; (D)-Q,S

12. (A)→(P,R,T); (B)→(Q,S); (C)→(P,S,T); (D)→(P, S, T)

13. (A) S, (B) R, (C) Q, (D) P

14. B **15.** D **16.** D **17.** A **18.** D

19. C **20.** B **21.** C **22.** A **23.** C

24. 0.3 **25.** 4R from O

26. 9 cm from center of bigger circle (leftwards)

27. $x=\frac{3a}{4}$ **28.** $\frac{\sqrt{13}}{2}v_0$ **29.** $d\le\frac{eu^2}{g(1+e)}$ **30.** $m\left(-3\hat{i}+4\hat{j}\right)$, $e=\frac{9}{16}$

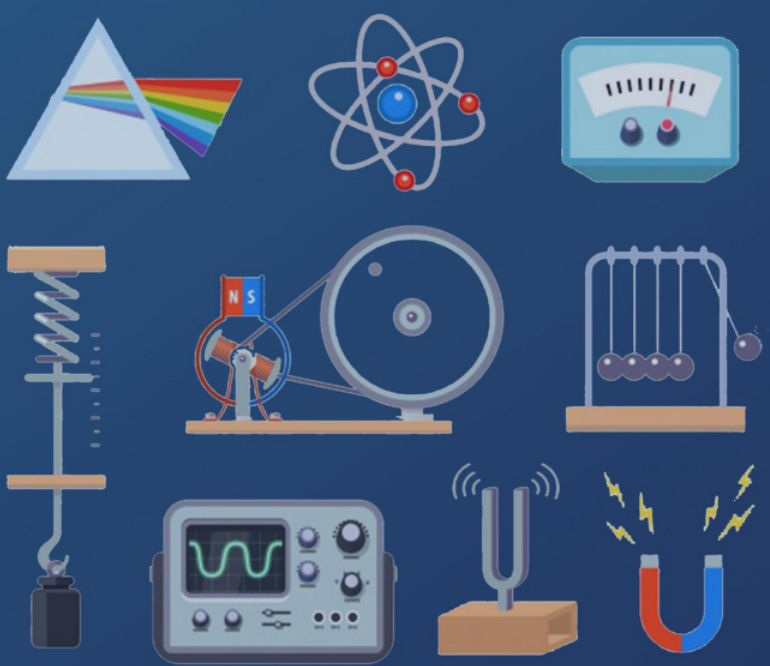
31. (a) 50 m (b) 25 m **32.** (i) 4 m/s, (ii) 24 J

33. (i) 3 J, (ii) $\frac{12}{5}$ N-s **34.** (i) $\frac{40}{3}$ m, (ii) t_e = 3.25 s

-: Important Notes & Formulas :-

PHYSICS

Circular Motion



SHEET

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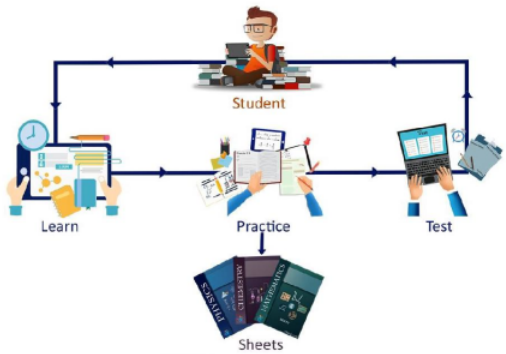
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr. No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Angular Variables	1,2,3			
2	Kinematics of Uniform Circular Motion	4,5	1		
3	Kinematics of Non-Uniform Circular Motion	6,7	2,4	1,2,3,4	1,4
4	Curvilinear Motion	8		5	2,6,7
5	Dynamics of Circular Motion	9,10,11,12	5,6,7,8,9	6,7,8	5,8
6	Banking of Roads		3	9	9,10
7	Centrifugal Force	13,14,15		10	
8	Angular Velocity in General	16,17,18	10		3

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Angular Variables

Q1. A wheel is of diameter 1m. If it makes 30 revolution per second, then the linear speed of a point on its circumference will be :-

(A) 30 π m/s (B) π m/s

(C) 60 π m/s (D) $\frac{\pi}{2}$ m/s

Q2. A wheel is rotating at 900 rpm about its axis when the power is cut off. It comes to rest in one minute. The angular retardation (assuming it to be uniform) in radian/sec^2 is:

(A) $\frac{\pi}{2}$ (B) $\frac{\pi}{4}$

(C) $\frac{\pi}{6}$ (D) $\frac{\pi}{8}$

Q3. A wheel initiallly at rest starts moving about its axis with constant angular acceleration. In first 2sec. it rotates through angle θ_1 and in further 2sec. it rotates through angle θ_2. The ratio θ_2/θ_1 is :-

(A) 1 (B) 2

(C) 3 (D) 5

Kinematics of Uniform Circular Motion

Q4. In uniform circular motion :-

(A) Velocity is constant

(B) Acceleration is constant

(C) Speed is constant

(D) Linear momentum is constant

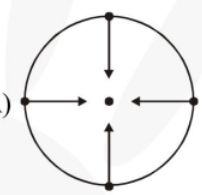
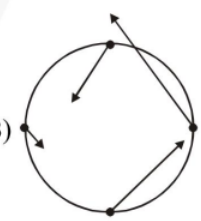
Q5. Two cars of masses m_1 & m_2 are moving along the circular paths of radius r_1 & r_2 respectively. Their speeds are such that they complete one round in same time. The ratio of angular speeds of two cars is :-

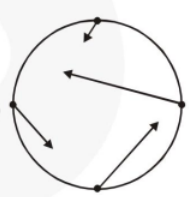
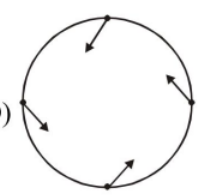
(A) $m_1 : m_2$ (B) $r_1 : r_2$

(C) 1 : 1 (D) $m_1r_1 : m_2r_2$

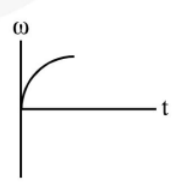
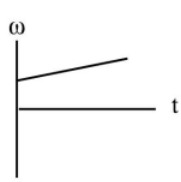
Kinematics of Non-Uniform Circular Motion

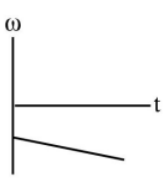
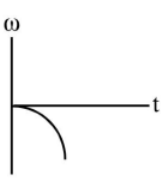
Q6. A car speeds up with constant magnitude of tangential acceleration in circular path moving in anticlockwise direction. Which of the following figure represents acceleration of the car?

(A)  (B) 

(C)  (D) 

Q7. The graphs below show angular velocity as a function of time. In which one is the magnitude of the angular acceleration constantly decreasing?

(A)  (B) 

(C)  (D) 

Curvilinear Motion

Q8. A body is projected with a velocity 10 ms^{-1} at an inclination 45° to the horizontal. Minimum radius of curvature of the trajectory described by the particle is _____.

(A) 5m (B) 10 m

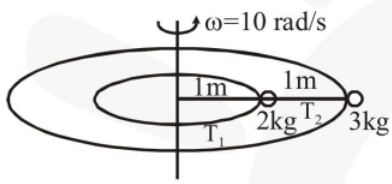
(C) 0 m (D) 2.5 m

Dynamics of Circular Motion

Q9. A stone of mass 1 kg, tied to the end of a string of length 1 m, is whirled in a horizontal circle with a uniform angular velocity of 2 rad/s. The tension in the string is (in N) :

(A) 2 (B) 1/2 (C) 4 (D) 1/4

Q10. Two particles of mass 2 kg and 3 kg connected to a rope of length 2m as shown and the system is revolved in horizontal circular path with angular velocity of 10 rad/s then what will be the value of tension T_1 and T_2 :-



(A) 200 N, 600 N (B) 600 N, 200 N

(C) 800 N, 600 N (D) 600 N, 800 N

Q11. What is the minimum radius of a circle along which a cyclist can ride with a velocity 18 km/hr if the coefficient of friction between the tyres and the road is $\mu = 0.5$

(take $g = 10\ m/s^2$).

(A) 5 m (B) 10 m

(C) 2 m (D) None of these

Q12. A mass is revolving in a circle which lies in a plane of paper. The direction of angular acceleration can be :-

(A) perpendicular to radius and velocity

(B) towards the radius

(C) tangential

(D) at right angle to angular velocity

Centrifugal Force

Q13. A man is standing on a rough ($\mu = 0.5$) horizontal disc rotating with constant angular velocity of 5 rad/sec. At what distance from centre should he stand so that he does not slip on the disc?

(A) $R \le 0.2$ m (B) $R > 0.2$ m

(C) $R > 0.5$ m (D) $R > 0.3$ m

Q14. A particle of mass m is tied to a light string and rotated with a speed v along a circular path of radius r. If T = tension in the string and mg = gravitational force on the particle then the actual forces acting on the particle are :

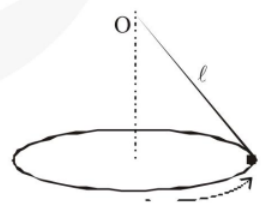
(A) mg and T only

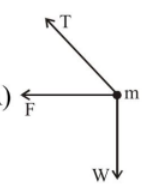
(B) mg, T and an additional force of $\frac{mv^2}{r}$ directed inwards.

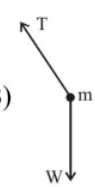
(C) mg, T and an additional force of $\frac{mv^2}{r}$ directed outwards.

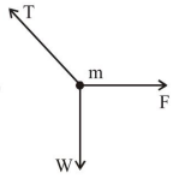
(D) only a force $\frac{mv^2}{r}$ directed outwards

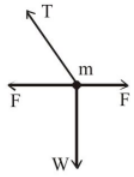
Q15. A point mass m is suspended from a light thread of length ℓ, fixed at O, is whirled in a horizontal circle at constant speed as shown. From your point of view, stationary with respect to the mass, the forces on the mass are :



(A) 

(B) 

(C) 

(D) 

Angular Velocity in General

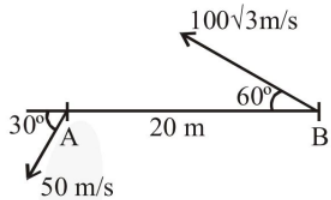
Q16. A body is executing circular motion in the vertical plane containing directions. If the direction of velocity $(\vec{v})$ at the top most point is towards west, what is the direction of angular velocity $(\vec{\omega})$?

(A) east (B) west
(C) north (D) south

Q17. If the magnitude of velocity in the previous question is decreasing with time, what is the direction of angular acceleration $(\vec{\alpha})$?

(A) east (B) west (C) north (D) south

Q18. Velocity of two particles A and B separated by distance 20 m apart is as shown in figure then what will be the angular velocity of B with respect to A



(A) 4.75 rad/s (B) 8.75 rad/s
(C) 16.75 rad/s (D) None of these

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Which of the following statements is/are TRUE for a particle moving in a circle with a constant angular speed ?

(A) The velocity vector is tangent to the circle
(B) The acceleration vector is tangent to the circle
(C) The acceleration vector points to the centre of the circle
(D) The velocity and acceleration vectors are perpendicular to each other

Q2. A particle is performing non uniform circular motion. Choose the CORRECT statement(s) :-

(A) The particle moves with variable speed
(B) The acceleration is always normal to velocity
(C) The particle moves with variable acceleration
(D) Net Acceleration and velocity are parallel to each other always.

Q3. For a curved track of radius R, banked at angle θ (Take $v_0 = \sqrt{Rg\tan\theta}$).

(A) a vehicle moving with a speed v_0 is able to negotiate the curve without calling friction into play at all
(B) a vehicle moving with any speed $v > v_0$ is always able to negotiate the curve, with friction called into play
(C) a vehicle moving with any speed $v < v_0$ must have the force of friction into play
(D) the minimum value of the angle of banking for a vehicle parked on the banked road can stay there without slipping, is given by $\theta = \tan^{-1}\mu_0$ (μ_0 = coefficient of static friction)

MATCHING LIST TYPE

Each question has THREE(03) ***matching lists : LIST I , LIST II and LIST III*** *FOUR options are given representing matching of elements from LIST I , LIST II and LIST III ONLY ONE of these four options corresponds to a correct matching.For each question, choose the option corresponding to the correct matching.*

Q4. A particle move in a circular path with varying $\theta = 3t^3 - 5t^2 + 4$, then -

	TIME	ANGULAR VELOCITY	ANGULAR ACCELERATION
(1)	t = 2	(P) 0 rad/sec	(L) 26 rad/sec^2
(2)	t = 10/9	(Q) 16 rad/sec	(M) 10 rad/sec^2
(3)	t = 0	(R) 51 rad/sec	(N) – 10 rad/sec^2
(4)	t = 3	(S) 14 rad/sec	(O) 44 rad/sec^2

(A) (1) → Q, L; (2) → P, M;(3) → P, N; (4) → R,O
(B) (1) → Q, N; (2) → Q, M;(3) → P, N; (4) → R,O
(C) (1) → Q, L; (2) → P, M;(3) → R, N; (4) → R,O
(D) (1) → S, L; (2) → P, M;(3) → P, N; (4) → R,O

PARAGRAPH TYPE

This section contains ***PARAGRAPHS****. Based on each paragraph, there are questions. Each question has FOUR options.* ***ONLY ONE*** *of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

A block is rotating in a circular track and angular speed of the block is given $\omega = at^2$, where ω is in rad/s and t is in seconds, a is a constant and equal to 2 rad/s^3. Mass of the block is 1 kg. Radius of circular track is 1 m.

Q5. Net force acting on the block at t = 2 s is -

(A) 8 N (B) $8\sqrt{65}$ N
(C) 32 N (D) 4 N

Q6. Angle between velocity vector and acceleration vector is -

(A) less than 90°
(B) greater than 90°
(C) equal to 90°
(D) data is insufficient

Q7. Time at which rate of change of speed is equal to $\frac{1}{\sqrt{2}}$ times of net acceleration -

(A) $\frac{1}{2}$s (B) 1s
(C) 2s (D) 4s

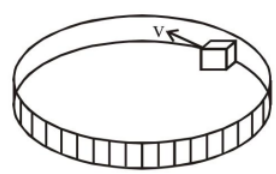
SUBJECTIVE TYPE

Q8. A block of mass m moves with speed v against a smooth, fixed vertical circular groove of radius r kept on smooth horizontal surface.

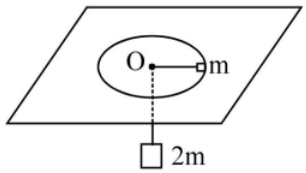
Find :

(i) normal reaction of the floor on the block.

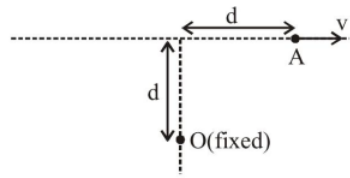
(ii) normal reaction of the vertical wall on the block.



Q9. A mass m rotating freely in a horizontal circle of radius 1 m on a frictionless smooth table supports a stationary mass 2m, attached to the other end of the string passing through smooth hole O in table, hanging vertically. Find the angular velocity of rotation.



Q10. Find angular velocity of A with respect to O at the instant shown in the figure.



Exercise - 2 — *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. If angular velocity of a disc depends an angle rotated θ as $\omega = \theta^2 + 2\theta$, then its angular acceleration at $\theta = 1$ rad is :-

(A) 8 rad/sec^2 (B) 10 rad/sec^2

(C) 12 rad/sec^2 (D) None

Q2. A car is moving on a circular path of radius 500m with a speed of 30 m/s at some instant. If its speed increases at the rate of 2m/s^2, its resultant acceleration at that instant is :-

(A) 2.5 m/s^2 (B) 2.7 m/s^2

(C) 7.2 m/s^2 (D) 4.0 m/s^2

Q3. A particle is moving on a circular path with a velocity $v = 1.5\ t^2 + 2t$, where v is in m/s and t in seconds. If radius of circular path is 2cm, then angular acceleration of the particle at $t = 2$s is :-

(A) 4 rad/s^2 (B) 40 rad/s^2

(C) 400 rad/s^2 (D) 0.4 rad/s^2

Q4. Let $\vec{v}(t)$ be the velocity of a particle at time t. Then INCORRECT statement is:

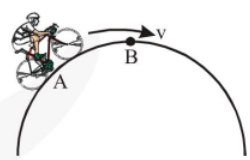
(A) $|d\vec{v}(t) / dt|$ and $d|\vec{v}(t)| / dt$ are always equal

(B) $|d\vec{v}(t) / dt|$ and $d|\vec{v}(t)| / dt$ may be equal

(C) $d|\vec{v}(t)| / dt$ can be zero while $|d\vec{v}(t) / dt|$ is not zero

(D) $d|\vec{v}(t)| / dt \neq 0$ implies $|d\vec{v}(t) / dt| \neq 0$

Q5. A motorcylist is going on an overbridge of radius r maintaining a constant speed v. As the motorcyclist goes up on the overbridge, the normal force :-



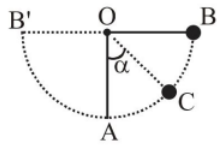
(A) Increases ($N_B > N_A$)

(B) Decreases ($N_B < N_A$)

(C) Remains same ($N_B = N_A$)

(D) Nothing can be said

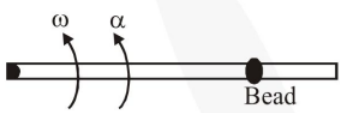
Q6. A simple pendulum is vibrating with an angular amplitude of 90° as shown in the adjoining figure. For what value of α, is the acceleration directed horizontally :-



(A) 0° (B) $\cos^{-1}\left(\frac{1}{\sqrt{3}}\right)$

(C) 90° (D) $\cos^{-1}\left(\frac{2}{3}\right)$

Q7. A bead is constrained to move on rod in gravity free space as shown in figure. The rod is rotating with angular velocity ω and angular acceleration α about its end. If μ is coefficient of friction. Mark the correct option. (Rod rotates in the plane of paper.)



(A) If $\mu = \frac{\omega^2}{\alpha}$ friction on bead is static in nature

(B) If $\mu \geq \frac{\omega^2}{\alpha}$ friction on bead is kinetic in nature

(C) If $\mu \leq \frac{\omega^2}{\alpha}$ friction is static

(D) If bead does not slide relative to rod. Friction will not exist between bead and rod.

Q8. A ring of radius r and mass per unit length m rotates with an angular velocity ω in free space. The tension in the ring is :

(A) zero (B) $\frac{1}{2}m\omega^2r^2$

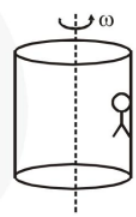
(C) $m\omega^2r^2$ (D) $mr\omega^2$

Q9. A circular road of radius 1000 m has banking angle 45°. The maximum safe speed of a car having a mass 2000 kg will be nearly, if the coefficient of friction between tyre and road is 0.5 :-

(A) 172 m/s (B) 124 m/s

(C) 99 m/s (D) 86 m/s

Q10. In a rotar a hollow vertical cylindrical structure rotates about its axis and a person rests against the inner wall. At a perticular speed of the rotar, the floor below the person is removed and the person hangs resting against the wall without any floor. If radius of rotar is 2m and $\mu_s = 0.2$ what will be the minimum angular velocity at which floor may be removed :-



(A) 2 rad/s (B) 5 rad/s

(C) 10 rad/s (D) None of them

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A particle is moving in a circular path and its acceleration vector is making an angle of 30° with the velocity vector and the magnitude of acceleration is 2 m/s^2, then -

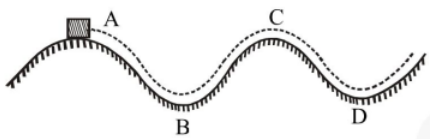
(A) Centripetal acceleration of particle 1 m/s^2

(B) Centripetal acceleration of particle $\sqrt{3}$ m/s^2

(C) Tangential acceleration of particle $\sqrt{3}$ m/s^2

(D) Tangential acceleration of particle 1 m/s^2

Q2. A body is moving with constant velocity on the path shown.



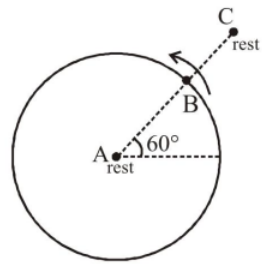
(A) Normal reaction exerted on body by path is greatest at N_B

(B) Normal reaction exerted on body by path is least at N_C

(C) Normal force is greater than weight at B

(D) Normal force is lesser than weight at A, D

Q3. Diagram shows three particles A, B & C. Particle B is moving in a circle of radius R with constant angular velocity ω anti-clockwise, A & C are at rest, AB = BC = R. Choose the correct statement(s).



(A) Angular velocity of B wrt A is ω clockwise

(B) Angular velocity of B wrt A is ω anticlockwise

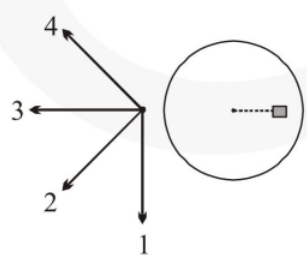
(C) Angular velocity of B wrt C is constant & equal to ω

(D) Angular velocity of B wrt C is not constant and is ≤ ω

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q4. A block is placed on a horizontal table which can rotate about its axis.The block is placed at a certain distance from centre as shown in figure. Table rotates such that particle does not slide. Select possible direction of net acceleration of block at the instant shown in figure.



	Column-I	**Column-II**
(A)	When rotation is clockwise with constant ω	(P) 1
(B)	When rotation is clock wise with decreasing ω	(Q) 2
(C)	When rotation is clockwise with increasing ω	(R) 3
(D)	Just after clockwise rotation begins from rest	(S) 4

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q5. A block of mass m = 20 kg is kept at a distance R = 1m from central axis of rotation of a round turn table (A table whose surface can rotate about central axis). Table starts from rest and rotates with constant angular acceleration, α = 3 rad/sec^2. The friction coefficient between block and table is $\mu = 0.5$. At time $t = \frac{x}{3}$ sec from starting of motion (i.e. t = 0 sec) the block is just about to slip. Find the value of x.

SUBJECTIVE TYPE

Q6. A stone is thrown horizontally with the velocity 15m/s. Determine the tangential and normal accelerations of the stone in 1 second after it begins to move.

Q7. A stone is launched upward at 45° with speed v_0. A bee follows the trajectory of the stone at a constant speed equal to the initial speed of the stone.

(i) Find the radius of curvature at the top point of the trajectory.

(ii) What is the acceleration of the bee at the top point of the trajectory? For the stone, neglect the air resistance.

Q8. A thin circular loop of radius R rotates about its vertical diameter with an angular frequency ω. Show that a small bead on the wire loop remains at its lowermost point for $\omega \le \sqrt{g/R}$. What is the angle made by the radius vector joining the centre to the bead with the vertical downward direction for $\omega = \sqrt{2g/R}$? Neglect friction.

Q9. An aircraft executes a horizontal loop at a speed of 720 km/h with its wings banked at 15°. What is the radius of the loop ?

Q10. A circular racetrack of radius 300 m is banked at an angle of 15°. If the coefficient of friction between the wheels of a race-car and the road is 0.2, what is the (a) optimum speed of the race-car to avoid wear and tear on its tyres, and (b) maximum permissible speed to avoid slipping ?

Answer Key

Ex-1											
1	2	3	4	5	6	7	8	9	10	11	12
A	A	C	C	C	C	A	A	C	C	A	A
13	14	15	16	17	18						
A	A	C	D	C	B						

Ex- 1A

1. A, C, D **2.** A, C **3.** A, C **4.** A **5.** B

6. A **7.** B **8.** (i) $N_F = mg$, (ii) $N_W = \frac{mv^2}{r}$.

9. $\sqrt{2g}$ rad/s **10.** $\frac{v}{2d}$

Ex-2									
1	2	3	4	5	6	7	8	9	10
C	B	C	A	A	B	A	C	A	B

Ex- 2A

1. A, C **2.** A, B, C **3.** B, D **4.** (A)-R; (B)-S; (C)-Q; (D)-P

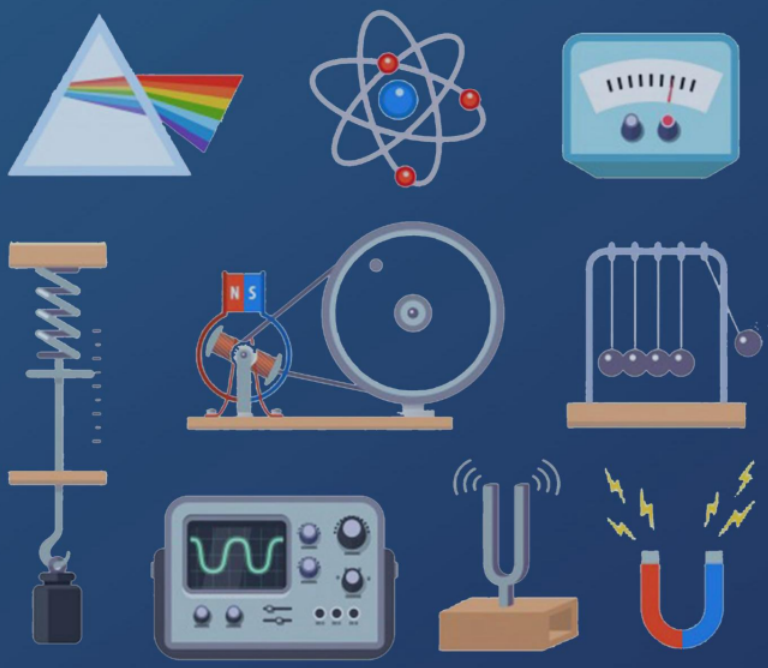
5. 2 **6.** $a_t = \frac{20}{\sqrt{13}}$, $a_n = \frac{30}{\sqrt{13}}$ **7.** (i) $\frac{V_0^2}{2g}$, (ii) 2g

8. 60° **9.** 15 km **10.** (a) 28.3 m/s (b) $v_{max} = 38.4\ ms^{-1}$.

-: Important Notes & Formulas :-

PHYSICS

Communication System



SHEET

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Contents

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2.	Homework Index	Page - iii
3.	Exercise 1	Page - 1
4.	Exercise 2	Page - 2
5.	Answer Key	Page - 4

Note

Detailed solutions are available on the eSaral App.

Module Description

For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-2
1	Introduction	1,2	
2	Propagation of Waves	3-9	1,2
3	Modulation and its types	10,11	3-5
4	Amplitude Modulation	12-14	6-13

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Introduction

Q1. A basic communication system consists of
(A) transmitter
(B) information source.
(C) user of information
. (D) channel
(E) receiver.
Choose the correct sequence in which these are arranged in a basic communication system :
(A) ABCDE (B) BADEC
(C) BDACE (D) BEADC

Q2. The process of superimposing signal frequency (i.e. audio wave) on the carrier wave is known as :
(A) Transmission (B) Reception
(C) Modulation (D) Detection

Propagation of waves

Q3. Frequencies in the UHF range normally propagate by means of :-
(A) Ground waves (B) Sky waves
(C) Satellite waves (D) Space waves

Q4. Long distance short-wave radio broad-casting generally uses :-
(A) Ground wave
(B) Ionospheric wave
(C) Direct wave
(D) Sky wave

Q5. For television broadcasting, the frequency employed is normally :-
(A) 30 – 300 MHz
(B) 30 – 300 GHz
(C) 30 – 300 KHz
(D) 30 – 300 Hz

Q6. In short wave communication waves of which of the following frequencies will be reflected back by the ionospheric layer having electron density 10^{11} m^{-3} ?
(A) 2 MHz
(B) 10 MHz
(C) 12 MHz
(D) 18 MHz

Q7. Range of frequencies allotted for commercial FM radio broadcast is :-
(A) 88 to 108 MHz
(B) 88 to 108 kHz
(C) 8 to 88 MHz
(D) 88 to 108 GHz

Q8. The maximum distance upto which TV transmission from a TV tower of height h can be received is proportional to :-
(1) $h^{1/2}$ (2) h
(3) $h^{3/2}$ (4) h^2

Q9. For skywave propagation of a 10 MHz signal, what should be the minimum electron density in ionosphere –
(A) $\sim 1{\cdot}2 \times 10^{12}$ m^{-3}
(B) $\sim 10^6$ m^{-3}
(C) $\sim 10^{14}$ m^{-3}
(D) $\sim 10^{22}$ m^{-3}

Modulation and its types

Q10. In amplitude modulation :-

(A) Only the amplitude is changed but frequency remains same

(B) Both the amplitude and frequency change equally

(C) Both the amplitude and frequency change unequally

(D) None the these

Q11. In frequency modulation :-

(A) The amplitude of career wave varies according to the frequency of message signal

(B) The frequency of career wave varies according to the amplitude of message signal

(C) The frequency of career wave varies according to the frequency of message signal

(D) The amplitude of career wave varies according to the amplitude of message signal

Amplitude Modulation

Q12. AM is used for broadcasting because :-

(A) It is more noise immune than other modulation systems

(B) It requires less transmitting power compared with other systems

(C) Its use avoids receiver complexity

(D) No other modulation system can provide faithful transmission for the necessary bandwidth

Q13. In an amplitude modulated wave for audio-frequency of 500 cycles/second, the appropriate carrier frequency will be :-

(A) 50 cycles/sec.

(B) 100 cycles/sec.

(C) 500 cycles/sec

(D) 50,000 cycles/sec.

Q14. An antenna is of height 500 m. What will be its range (Radius of the earth is 6400 km)?

(A) 800 km (B) 100 km

(C) 50 km (D) 80 km

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. The maximum range of ground or surface wave propagation depends on :-

(A) The frequency of the radio waves only

(B) Power of the transmitter only

(C) Both of them

(D) None of them

Q2. Three waves A, B and C of frequencies 1600 kHz, 5 MHz and 60 MHz, respectively are to be transmitted from one place to another. Which of the following is the most appropriate mode of communication :

(A) A is transmitted via space wave while B and C are transmitted via sky wave.

(B) A is transmitted via ground wave, B via sky wave and C via space wave.

(C) B and C are transmitted via ground wave while A is transmitted via sky wave.

(D) B is transmitted via ground wave we while A and C are transmitted via space wave.

Q3. If a carrier wave of 1000 kHz is used to carry the signal, the length of transmitting antenna will be equal to :-

(A) 3 m (B) 30m

(C) 75 m (D) 3000 m

Q4. **Statement-1 :** An audio signal is transmitted over long distances by translating it into high frequency wave.

Statement-2 : Size of transmitting antenna is to be at least $\lambda/4$ in dimension.

(A) Statement-1 is true, statement-2 is true and statement-1 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation of statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

Q5. Modulation factor determines :-

(A) Only the strength of the transmitted signal

(B) Only the quality of the transmitted signal

(C) Both the strength and quality of the signal

(D) None of the above

Q6. Which of the following is/are the limitations of amplitude modulation ?

(A) Clear reception

(B) High efficiency

(C) Small operating range

(D) Good audio quality

Q7. For a carrier frequency of 100 kHz and a modulating frequency of 5 kHz what is the width of AM transmission :-

(A) 5 kHz (B) 10kHz

(C) 20 kHz (D) 200 KHz

Q8. A speech signal of 3kHz is used to modulate a carrier signal of frequency 1 MHz, using amplitude modulation. The frequencies of the side bands will be :

(A) 1.003 MHz and 0.997 MHz.

(B) 3001 kHz and 2997 kHz.

(C) 1003 kHz and 1000 kHz.

(D) 1 MHz and 0.997 MHz.

Q9. A message signal of frequency ω_m is superposed on a carrier wave of frequency ω_c to get an amplitude mediated wave (AM). The frequency of the AM wave will be :

(A) ω_m (B) ω_c

(C) $\frac{\omega_c + \omega_m}{2}$ (D) $\frac{\omega_c - \omega_m}{2}$

Q10. Identify the mathematical expression for amplitude modulated wave :

(A) $A_c \sin [\{\omega_c + kv_m(t)\}t + \phi]$

(B) $A_c \sin \{\omega_c t + \phi + k_2 v_m(t)\}$

(C) $\{A_c + kv_m(t)\} \sin (\omega_c t + \phi)$

(D) $A_c + v_m(t) \sin (\omega_c t + \phi)$

Q11. $C(t)$ and $m(t)$ are used to generate an AM signal. The modulation index of generated AM signal is 0.5.

Then the quantity $\frac{P_{\text{Total SB}}}{P_{\text{Carrier}}} =$

(A) 1/8 (B) 1/4 (C) 2/3 (D) 9/8

Q12. A message signal $m(t) = 4\cos 2000\pi t$ modulates the carrier $C(t) = \cos 2\pi f_c t$ where $f_c = 1\text{MHz}$ to produce an AM signal. For demodulation using envelope detector the time constant RC should satisfy

(A) $0.5\text{ms} < RC < 1\text{ms}$

(B) $1\mu\text{s} \leq RC \leq 0.5\text{ms}$

(C) $RC \leq 1\mu\text{s}$

(D) $RC \geq 1\mu\text{s}$

Q13. The antenna current of an AM transmitter is 8 *A* when only carrier is sent but increases to 8.96 *A* when the carrier is modulated sinusoidally. The percentage modulation is:

(A) 50% (B) 60% (C) 65% (D) 71%

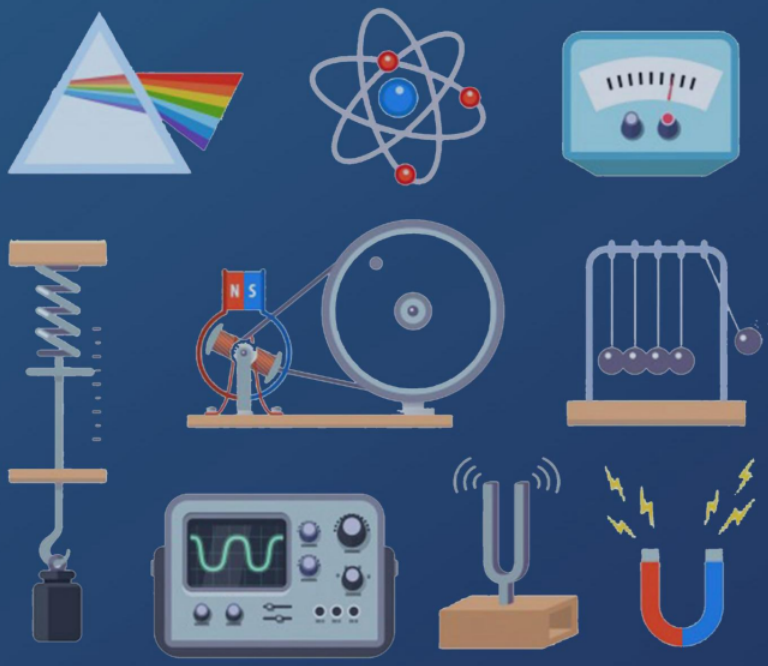
Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	C	D	B	A	A	A	A	A	A
11	**12**	**13**	**14**						
B	C	D	D						

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	B	C	A	C	C	B	A	B	C
11	**12**	**13**							
A	B	D							

PHYSICS

Current Electricity



SHEET

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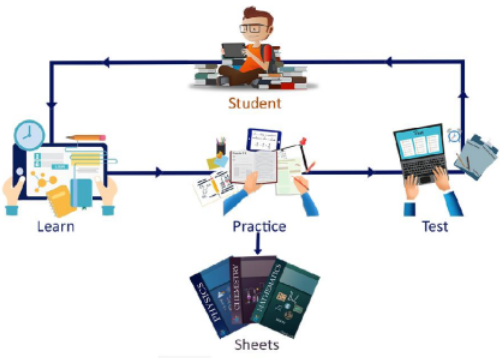
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Electric Current	1	12		
2	Drift Velocity	2-8			
3	Ohm's Law	9		1	
4	Resistance and Resistors	10-14	13	2	
5	Battery And Emf	15	1,8,14		
6	Kirchhoff's Laws		9		
7	Series And Parallel Combination	16-19	15	3	
8	Circuit Solving	20,21	2,4-6,10	4	
9	Wheatstone Bridge	22		5	1
10	Series And Parallel Combination Of Batteries	23-26		6	
11	Power Delivered and Heat Dissipated	27-34		7-13	2-5
12	Using Ammeter and voltmeter	35-38	11	14-16	6
13	Constructing Ammeter and Voltmeter		16	17	7
14	Meter Bridge			18-20	8
15	Potentiometer	39,40	7	21	9-13,22
16	Post Office Box	41			
17	After full Chapter		3	22	14-21,23

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Electric Current

Q1. In the Bohr's model of hydrogen atom, the electron moves around the nucleus in a circular orbit of radius 5×10^{-11} m. Its time period is 1.5×10^{-16} s. The current associated with the electron motion is :-

(A) zero (B) 1.6×10^{-19} A
(C) 0.17 A (D) 1.07×10^{-3} A

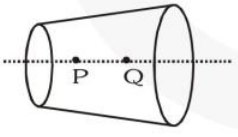
Drift Velocity

Q2. The number of free electrons per 10 mm of an ordinary copper wire is about 2×10^{21}. The average drift speed of the electrons is 0.25 mm/sec The current flowing is :-

(A) 0.8A (B) 8A
(C) 80A (D) 5A

Q3. A wire has a non–uniform cross–section as shown in figure. A steady current flows through it. The drift speed of electrons at points P and Q is v_P and v_Q, then

(A) $v_P = v_Q$
(B) $v_P < v_Q$
(C) $v_P > v_Q$
(D) data insufficient



Q4. There are 8.4×10^{22} free electrons per cm^3 in copper. The current in the wire is 0.21 A, then the drift velocity of electrons in a copper wire of $1mm^2$ cross-section will be $\left(e = 1.6 \times 10^{-19} C\right)$:-

(A) 2.12×10^{-5} m/s (B) 0.78×10^{-5} m/s
(C) 1.56×10^{-5} m/s (D) none of these

Q5. **Statement-1 :** The electric bulb glows immediately when switch is on.

Statement-2 : The drift velocity of electrons in a metallic wire is very high.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.
(B) Statement–1 is True, Statement–2 is True; Statement–2 is NOT a correct explanation for Statement–1.
(C) Statement–1 is True, Statement–2 is False.
(D) Statement–1 is False, Statement–2 is True.

Q6. An insulating pipe of cross-section area 'A' contains an electrolyte which has two types of ions → their charges being –e and +2e. A potential difference applied between the ends of the pipe result in the drifting of the two types of ions, having drift speed = v (–ve ion) and v/4 (+ve ion). Both ions have the same number per unit volume = n. The current flowing through the pipe is

(A) $\frac{1}{2}$ nev A (B) $\frac{1}{4}$ nev A
(C) $\frac{5}{2}$ nev A (D) $\frac{3}{2}$ nev A

Q7. A uniform copper wire carries a current i amperes and has p carriers per $metre^3$. The length of the wire is ℓ metres and its cross-section area is s $metre^2$. If the charge on a carrier is q coulombs, the drift velocity in ms^{-1} is given by

(A) $i/\ell sq$ (B) i/psq
(C) psq/i (D) $i/ps\ell q$

Q8. A current I flows through a uniform wire of diameter d when the mean electron drift velocity is v. The same current will flow through a wire of diameter d/2 made of the same material if the mean drift velocity of the electron is :

(A) v/4 (B) v/2
(C) 2v (D) 4v

Ohm's Law

Q9. **Statement–1 :** A metal has resistance and gets often heated by flow of current.

Statement–2 : When free electrons drift through a metal they makes occasional collisions with the lattice. These collisions are inelastic and transfer energy to the lattice as internal energy.

(A) Statement–1 is True, Statement–2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement–1 is True, Statement–2 is True; Statement-2 is NOT a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Resistance and Resistors

Q10. Three copper wires of lengths and cross-sectional areas are (ℓ, A); $\left(2\ell, \frac{A}{2}\right)$ and $\left(\frac{\ell}{2}, 2A\right)$. Resistance will be minimum in:-

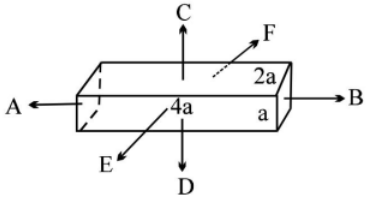
(A) wire of cross-sectional area $\frac{A}{2}$

(B) wire of cross-sectional area A

(C) wire of cross-sectional area 2A

(D) same is all the three cases

Q11. A conductor with rectangular cross section has dimensions (a×2a×4a) as shown in figure. Resistance across AB is x, across CD is y and across EF is z. Then -



(A) x = y = z (B) x > y > z

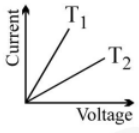
(C) y > x > z (D) x > z > y

Q12. When a wire of uniform cross-section a, length ℓ and resistance R is bent into a complete circle, resistance between any two of diametrically opposite points will be :–

(A) $\frac{R}{2}$ (B) $\frac{R}{4}$

(C) $\frac{R}{8}$ (D) 4R

Q13. The current in a metallic conductor is plotted against voltage at two different temperatures T_1 and T_2. Which is correct



(A) $T_1 > T_2$ (B) $T_1 < T_2$

(C) $T_1 = T_2$ (D) none

Q14. Two resistance R_1 and R_2 are made of different materials. The temperature coefficient of the material of R_1 is α and of the material of R_2 is $-\beta$. The resistance of the series combination of R_1 and R_2 will not change with temp., then ratio of resistance of two wire at 0°C will be :

(A) $\frac{\alpha}{\beta}$ (B) $\frac{\alpha+\beta}{\alpha-\beta}$

(C) $\frac{\alpha^2+\beta^2}{\alpha\beta}$ (D) $\frac{\beta}{\alpha}$

Battery And Emf

Q15. A battery has e.m.f. 4V and internal resistance 'r'. When this battery is connected to an external resistance of 2 ohms, a current of 1 amp. flows in the circuit. How much current will flow if the terminals of the battery are connected directly :–

(A) 1 A (B) 2 A

(C) 4 A (D) infinite

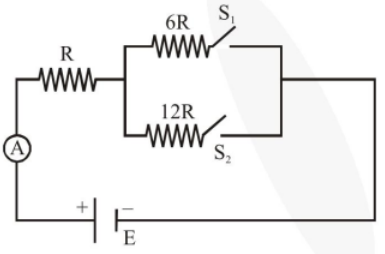
Series And Parallel Combination

Q16. The equivalent resistance of a group of resistances is R. If another resistance is connected in parallel to the group, its new equivalent becomes R_1 and if it is connected in series to the group, it new equivalent becomes R_2 we have :

(A) $R_1 > R$ or $R_2 > R$ (B) $R_1 < R$ or $R_2 > R$

(C) $R_1 > R$ or $R_2 < R$ (D) $R_1 < R$ or $R_2 < R$

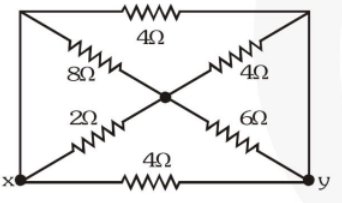
Q17. When only S_1 is closed then reading of ammeter is I_1, when only S_2 is closed then reading I_2, when both S_1 & S_2 are closed simultaneously then reading is I_3 then :-



(A) $I_1 > I_2 > I_3$ (B) $I_2 > I_3 > I_1$

(C) $I_3 > I_2 > I_1$ (D) $I_3 > I_1 > I_2$

Q18. The total resistance between x and y in ohm is :–



(A) 1 Ω (B) 4 Ω

(C) (4/3) Ω (D) (2/3) Ω

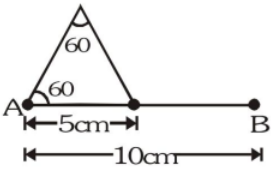
Q19. A wire has resistance of 24 Ω is bent in the following shape. The effective resistance between A and B is-

(A) 24 Ω

(B) 10 Ω

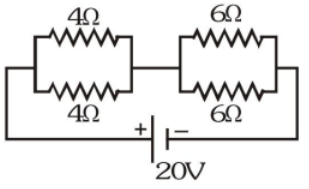
(C) $\frac{16}{3}\Omega$

(D) None of these



Circuit Solving

Q20. Four resistances are connected in a circuit as shown in the following diagram. The value of the current in ampere in 4Ω and 6Ω resistance are :-



(A) 2 and 4 (B) 1 and 2

(C) 1and 1 (D) 2 and 2

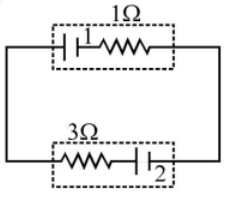
Q21. In the figure shown, battery 1 has emf = 6 V and internal resistance = 1 Ω. Battery 2 has emf = 2V and internal resistance = 3 Ω. The wires have negligible resistance. What is the potential difference across the terminals of battery 2 ?

(A) 4 V

(B) 1.5 V

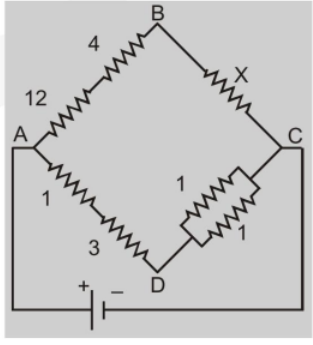
(C) 5 V

(D) 0.5 V



Wheatstone Bridge

Q22. In the arrangement of resistances shown in the circuit, the potential difference between points B and D will be zero, when the unknown resistance X is :-

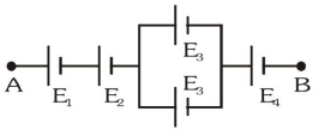


(A) 4 Ω (B) 3 Ω

(C) 2 Ω (D) 1 Ω

Series And Parallel Combination Of Batteries

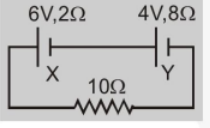
Q23. In the following circuit the resultant e.m.f. between AB is :–



(A) $E_1+E_2+E_3+E_4$ (B) $E_1+E_2+2E_3+E_4$

(C) $E_1+E_2+\frac{E_3}{2}+E_4$ (D) $E_1+E_2+\frac{E_3}{4}+E_4$

Q24. Two cells X and Y are connected to a resistance of 10Ω as shown in the figure. The terminal voltage of cell Y is :-



(A) zero (B) 2V

(C) 4V (D) 10V

Q25. 100 cells, each of e.m.f. 5 V and internal resitance 1 Ω, are to be arranged so as to produce maximum current in a 25 Ω resistance. Each row is to contain equal number of cells. The number of rows should be :-

(A) 2 (B) 4

(C) 5 (D) 10

Q26. Two nonideal batteries are connected in parallel consider the following statements:-

(A) The equivalent emf is smaller than either of the two emfs

(B) The equivalent internal resistance is smaller than either of the two internal resistances

(A) both A and B are correct

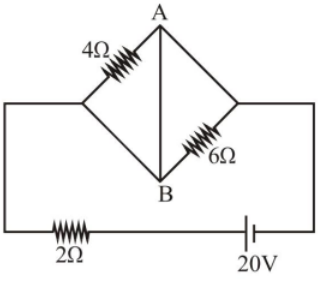
(B) A is correct but B is wrong

(C) B is correct but A is wrong

(D) both A and B are wrong

Power Delivered and Heat Dissipated

Q27. In the circuit shown in figure. Which of the following is the incorrect.



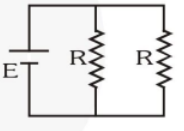
(A) Power supplied by the battery is 200W

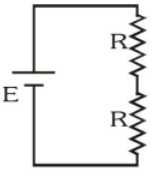
(B) Current flowing in the circuit is 5A

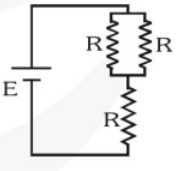
(C) Potential difference across the 4Ω resistance is equal to the potential difference across the 6Ω resistance.

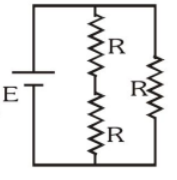
(D) Current in wire AB is not zero.

Q28. Consider four circuits shown in the figure below. In which circuit power dissipated is greater (Neglect the internal resistance of the power supply) :–

(A) 

(B) 

(C) 

(D) 

Q29. When a constant voltage is applied between the ends of a metal wire. Heat produced in this wire will be doubled if:

(A) both the length and the radius of the wire are halved.

(B) both the length and the radius of the wire are doubled.

(C) the radius of the wire is doubled.

(D) the length of the wire is doubled.

Q30. A lamp of 100 W and a heater of 1 kW are in simultaneous use for 10 hours. The units of electricity consumed according to the meter in the house is :

(A) 10 (B) 9 (C) 11 (D) 1

Q31. A 60 watt bulb operates on 220 V supply. The current flowing through the bulb is :-

(A) $\frac{11}{3}$A (B) $\frac{3}{11}$A

(C) 8 A. (D) 6 A.

Q32. An electric bulb is designed to draw power P_0 at voltage V_0. If the voltage is V, it draws a power P, then –

(A) $P = \left(\frac{V}{V_0}\right)P_0$ (B) $P = \left(\frac{V_0}{V}\right)P_0$

(C) $P = \left(\frac{V_0}{V}\right)^2 P_0$ (D) $P = \left(\frac{V}{V_0}\right)^2 P_0$

Q33. 'n' identical bulbs, each designed to draw a power P from a certain voltage supply are joined in series across the supply. The total power which they will draw is :–

(A) P (B) nP (C) $\frac{P}{n^2}$ (D) $\frac{P}{n}$

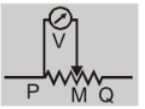
Q34. A battery of 10 V and internal resistance 0.5 Ω is conneted across a variable resistance R. The value of R for which the power delivered in its maximum state, is equal to:–

(A) 0.5 Ω (B) 1 Ω

(C) 1.5 Ω (D) 2 Ω

Using Ammeter and voltmeter

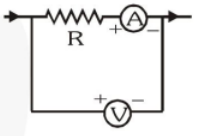
Q35. P, Q is a uniform wire of resistance 2000 Ω and M the mid point of PQ. A voltmeter of resistance 1000 Ω is connected between P and M. The reading of the voltmeter, when, the potential difference applied between PQ is 150 volt will be.



(A) 150 volt (B) 100 volt

(C) 75 volt (D) 50 volt

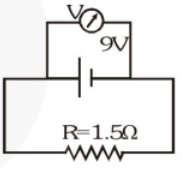
Q36. In the following circuit, the resistance of a voltmeter is 10,000 Ω and that of an ammeter is 20 Ω. If the reading of an ammeter is 0.1 amp. and that of voltmeter is 12 volt, then the value of R is :–



(A) 122 Ω (B) 100 Ω

(C) 118 Ω (D) 116 Ω

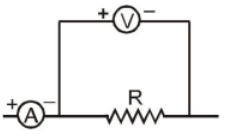
Q37. When a voltmeter is conected across the terminals of a cell, it measure 9 Volt. If a resistance of 1.5 Ω is connected across the terminals of a cell as shown in figure. Then current flowing through this resistance is :–



(A) 1.3 A (B) 6 A

(C) 9 A (D) 12 A

Q38. A student connects a non ideal voltmeter, ammeter and resistance according to the circuit given. If the voltmeter reading is 20 V and ammeter reading is 4 A, then the resistance will be :-



(A) equal to 5 Ω (B) more than 5 Ω

(C) less than 5 Ω (D) equal to 2 Ω

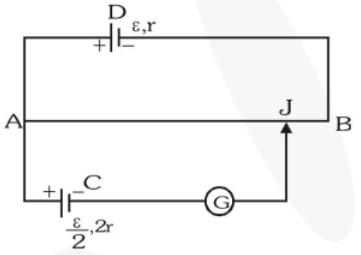
Potentiometer

Q39. A potentiometer wire has length 10 m and resistance 10Ω. It is connected to a battery of EMF 11 volt and internal resistance 1 Ω, then the potential gradient in the wire is

(A) 10 V/m (B) 1 V/m

(C) 0.1 V/m (D) none

Q40. In the figure, the potentiometer wire AB of length L and resistance 9r is joined to the cell D of emf ε and internal resistance r. The cell C's emf is $\frac{\varepsilon}{2}$ and its internal resistance is 2r. The galvanometer G will show no deflection when the length AJ is -

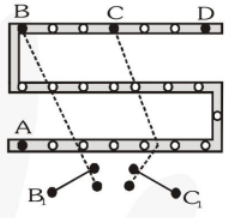


(A) $\frac{4L}{9}$ (B) $\frac{5L}{9}$

(C) $\frac{7L}{18}$ (D) $\frac{11L}{18}$

Post Office Box

Q41. For the post office box arrangement to determine the value of unknown resistance, the unknown resistance should be connected between.



(A) B and C (B) C and D

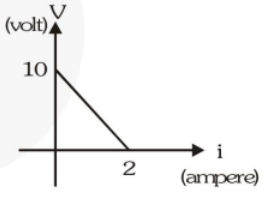
(C) A and D (D) B_1 and C

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A battery of emf E and internal resistance r is connected across a resistance R. Resistance R can be adjusted to any value greater than or equal to zero. A graph is plotted between the current (i) passing through the resistance and potential difference (V) across it. Select the correct alternative(s).



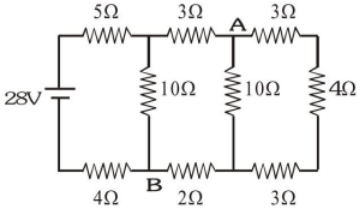
(A) Internal resistance of battery is 5Ω

(B) Emf of the battery is 20V

(C) Maximum current which can be taken from the battery is 4A

(D) V–i graph can never be a straight line as shown in figure

Q2. Consider the circuit shown in the figure :



(A) The current in the 5Ω resistor is 2A
(B) The current in the 5Ω resistor is 1A
(C) The potential difference $V_A - V_B$ is 7V
(D) The potential difference $V_A - V_B$ is 5V

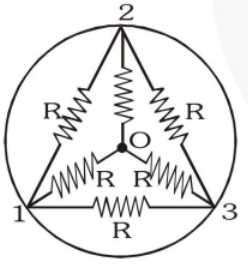
Q3. Two identical fuses are rated at 10A. If they are joined
(A) in parallel, the combination acts as a fuse of rating 20A
(B) in parallel, the combination acts as a fuse of rating 5A
(C) in series, the combination acts as a fuse of rating 10A
(D) in series, the combination acts as a fuse of rating 20A

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 4 to 6

Inside a super conducting ring six identical resistors each of resistance R are connected as shown in figure:



Q4. The equivalent resistance(s).
(A) between 1 & 3 is zero
(B) between 1 & 3 is R/2
(C) between 1 & 2, 2 & 3, 3 & 1 are all equal
(D) None of these

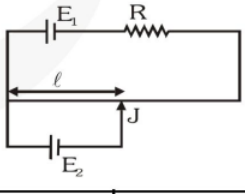
Q5. The equivalent resistance (s).
(A) between 0 & 1 is R
(B) between 0 & 1 is R/3
(C) between 0 & 1 is 0
(D) between 0 & 1, 0 & 2 and 0 & 3 are all equal

Q6. Imaging a battery of emf E between the point 0 and 1, with its positive terminal connected with O.
(A) The current entering at O is equally divided into three resistances.
(B) The current in the other three resistances R_{12}, R_{13}, R_{23} is zero.
(C) The resistances R_{02} and R_{03} have equal magnitudes of current while the resistance R_{01} have different current.
(D) Potential $V_2 = V_3 > V_1$

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q7. In the potentiometer arrangement shown in figure, null point is obtained at length ℓ.

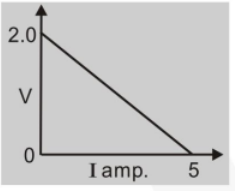


Column I	Column II
(A) If E_1 is increased	(P) ℓ should increase
(B) If R is increased	(Q) ℓ should decrease
(C) If E_2 is increased	(R) ℓ should remain the same to again get the null point

NUMERICAL TYPE

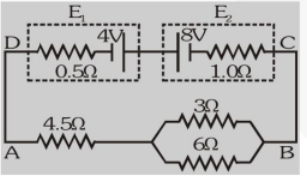
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q8. For a cell, the graph between the potential difference (V) across the terminals of the cells and the current I drawn from the cell is as shown in figure. Calculate the e.m.f. and the internal resistance of the cell.

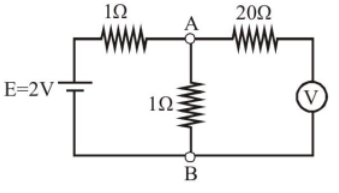


Q9. What is the value of current I in the following circuit ?

Q10. In the given circuit, calculate the value of current in 4.5 Ω resistor and indicate its direction. Also calculate potential difference across each cell.



Q11. In the given circuit, the voltmeter and the electric cell are ideal. Find the reading of the voltmeter (in volt)



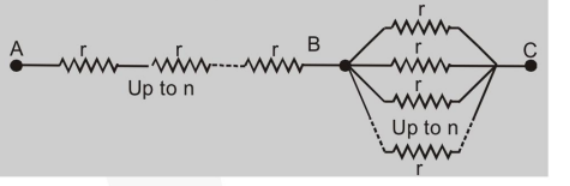
SUBJECTIVE TYPE

Q12. In hydrogen atom, the electron makes 6.62×10^{15} revolutions/sec. around the nucleus in an orbit of radius 0.5 Å. Calculate the equivalent current.

Q13. The dimension of a block is 100 m × 1 m × 1 m. The specific resistance of the material of the block is 4×10^{-6} Ω.m. Calculate its resistance across its square faces.

Q14. A battery of 10 cells each of e.m.f. E = 1.5 V and internal resistance 0.5 Ω has 1 cell wrongly connected. It is being charged by 220 V power supply with an external resistance of 47Ω in series. The potential difference across the battery.

Q15. In the following figure what is the resultant resistance between A and C ?



Q16. A galvanometer of resistance 100Ω gives full scale deflection for a current of 10^{-5} A. Calculate the shunt required to convert it into an ammeter of 1 ampere range.

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. The current density across a cylindrical conductor of radius R varies in magnitude according to the equation $J = J_0\left(1-\frac{r}{R}\right)$ where r is the distance from the central axis. Thus, the current denisty is a maximum J_0 at that axis (r = 0) and decreases linearly to zero at the surface (r = R). The current in terms of J_0 and conductor's cross-sectional area A is :-

(A) $\frac{J_0A}{3}$ (B) $\frac{J_0A}{6}$ (C) $\frac{J_0A}{2}$ (D) $\frac{J_0A}{5}$

Q2. A wire of cross-section area A, length L_1, resistivity ρ_1 and temperature coefficient of resistivity α_1 is connected to a second wire of length L_2, resistivity ρ_2, temperature coefficient of resistivity α_2 and the same area A, so that wire carries same current. Total resistance R is independent of temperature for small temperature change if (Thermal expansion effect is negligible).

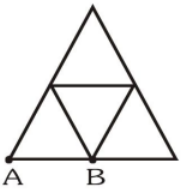
(A) $\alpha_1 = -\alpha_2$

(B) $\rho_1L_1\alpha_1 + \rho_2L_2\alpha_2 = 0$

(C) $L_1\alpha_1 + L_2\alpha_2 = 0$

(D) None

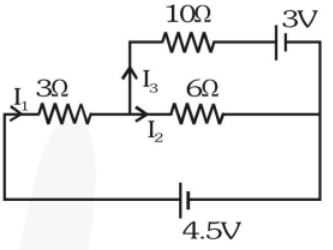
Q3. In the diagram resistance between any two junctions is R. Equivalent resistance across terminals A and B is



(A) $\frac{11R}{7}$ (B) $\frac{18R}{11}$

(C) $\frac{7R}{11}$ (D) $\frac{11R}{18}$

Q4. Find the current I_1, I_2, & I_3 in the circuit.



(A) $\frac{1}{2},\frac{1}{2},1$ (B) 1, 1, 2

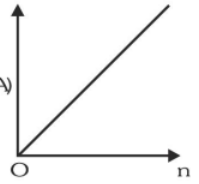
(C) $\frac{1}{2},\frac{1}{2},3$ (D) $\frac{1}{2},\frac{1}{2},0$

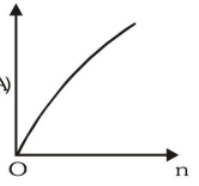
Q5. A Wheatstone's bridge is balanced with a resistance of 625 Ω in the third arm, where P, Q and S are in the 1st, 2nd and 4th arm respectively. If P and Q are interchanged, the resistance in the third arm has to be increased by 51Ω to secure balance. The unknown resistance in the fourth arm is

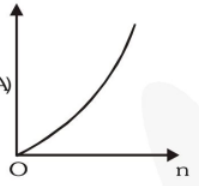
(A) 625 Ω (B) 650 Ω

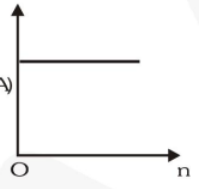
(C) 676 Ω (D) 600 Ω

Q6. A battery consists of a variable number n of identical cells having internal resistance connected in series. The terminals of the battery are short circuited and the current I measured. Which one of the graph below shows the correct relationship between I and n?

(A) 

(B) 

(C) 

(D) 

Q7. The charge flowing through a resistance R varies with time as $Q=2t-8t^2$. The total heat produced in the resistance is (for $0 \le t \le \frac{1}{8}$)

(A) $\frac{R}{6}$ joules (B) $\frac{R}{3}$ joules

(C) $\frac{R}{2}$ joules (D) R joules

Q8. Power generated across a uniform wire connected across a supply is H. If the wire is cut into n equal parts and all the parts are connected in parallel across the same supply, the total power generated in the wire is

(A) $\frac{H}{n^2}$ (B) n^2H

(C) nH (D) $\frac{H}{n}$

Q9. Two bulbs rated (25 W – 220V) and (100W – 220V) are connected in series to a 440 V line. Which one is likely to fuse?

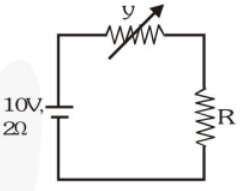
(A) 25 W bulb

(B) 100 W bulb

(C) both bulbs

(D) none

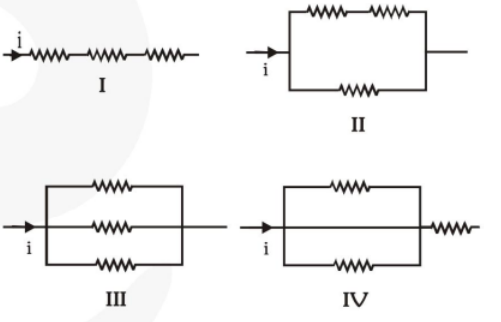
Q10. In the figure shown the power generated in y is maximum when y = 5Ω then R is -



(A) 2Ω (B) 6Ω

(C) 5Ω (D) 3Ω

Q11. The three resistance of equal value are arranged in the different combinations shown below. Arrange them in increasing order of power dissipation :



(A) III < II < IV < I

(B) II < III < IV < I

(C) I < IV < III < II

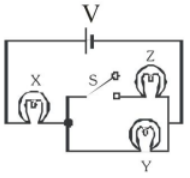
(D) I < III < II < IV

Q12. Two bulbs one of 200 volts, 60 watts & the other of 200 volts, 100 watts are connected in series to a 200 volt supply. The power consumed will be

(A) 37.5 watt (B) 160 watt

(C) 62.5 watt (D) 110 watt

Q13. If X, Y and Z in figure are identical lamps, which of the following changes to the brightness of the lamps occur when switch S is closed?



(A) X stays the same, Y decreases

(B) X increases, Y decreases

(C) X increases, Y stays the same

(D) X decreases, Y increases

Q14. A voltmeter of 998 ohm resistance is connected to a cell of emf 2 volt, having internal resistance of 2 ohms, The error in measuring emf will be :–

(A) 4×10^{-1} V (B) 2×10^{-3} V

(C) 4×10^{-3} V (D) 2×10^{-1} V

Q15. An ammeter and a voltmeter are joined in series to a cell. Their readings are A and V respectively. If a resistance is now joined in parallel with the voltmeter :-

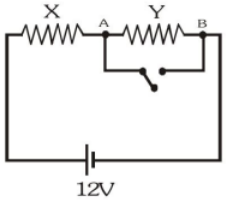
(A) both A and V will decrease.

(B) both A and V will increase.

(C) A will increase, V will decrease.

(D) A will decrease, V will increase.

Q16. When an ammeter of negligible internal resistance is inserted in series with circuit it reads 1A. When the voltmeter of very large resistance is connected across X it reads 1V. When the point A and B are shorted by a conducting wire, the voltmeters measures 10V across the battery. The internal resistance of the battery is equal to



(A) zero (B) 0.5Ω (C) 0.2Ω (D) 0.1Ω

Q17. A galvanometer has a resistance of 20Ω and reads full-scale when 0.2 V is applied across it. To convert it into a 10 A ammeter, the galvanometer coil should have a

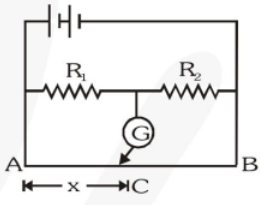
(A) 0.01Ω resistor connected across it

(B) 0.02Ω resistor connected across it

(C) 200Ω resistor connected in series with it

(D) 2000 Ω resistor connected in series with it

Q18. In the shown arrangement of the experiment of the meter bridge if AC corresponding to null deflection of galvanometer is x, what would be its value if the radius of the wire AB is doubled?

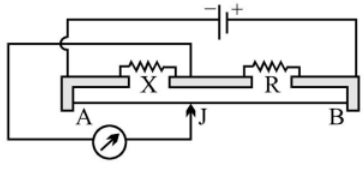


(A) x (B) x/4 (C) 4x (D) 2x

Q19. A resistance of 2Ω is connected across one gap of a metre–bridge (the length of the wire is 100 cm) and an unknown resistance, greater than 2Ω, is connected across the other gap. When these resistances are inter-changed, the balance point shifts by 20 cm. Neglecting any corrections, the unknown resistance is :-

(A) 3Ω (B) 4Ω (C) 5Ω (D) 6Ω

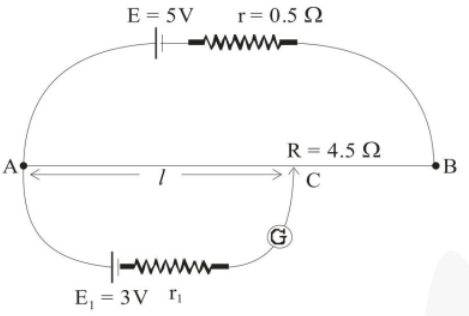
Q20. The figure shows a metre-bridge circuit, with AB = 100 cm, X = 12Ω and R = 18Ω, and the jockey J in the position of balance. If R is now made 8Ω, through what distance will J have to be moved to obtain balance?



(A) 10 cm (B) 20 cm

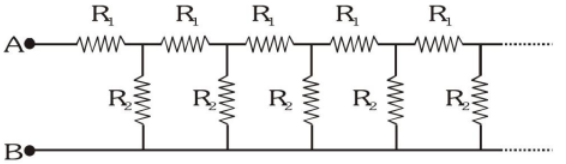
(C) 30 cm (D) 40 cm

Q21. In the given potentiometer circuit length of the wire AB is 3 m and resistance is R = 4.5 Ω. The length AC for no deflection in galvanometer is-



(A) 2 m (B) 1.8 m
(C) dependent on r_1 (D) none of these

Q22. Consider an infinite ladder network shown in figure. A voltage V is applied between the points A and B. This applied value of voltage is halved after each section. Then-



(A) $\frac{R_1}{R_2}=1$ (B) $\frac{R_1}{R_2}=\frac{1}{2}$

(C) $\frac{R_1}{R_2}=2$ (D) $\frac{R_1}{R_2}=3$

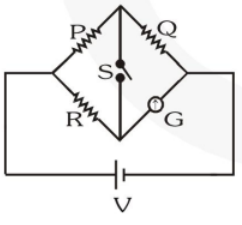
Exercise - 2A Brain Booster

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

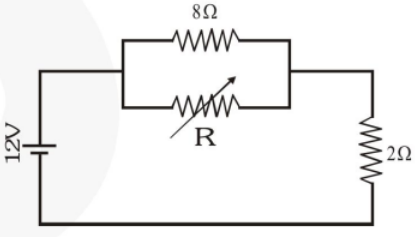
Q1. In the circuit shown P ≠ R, the reading of galvanometer is same with switch S open or closed. Then-

(A) $I_R = I_G$
(B) $I_P = I_G$
(C) $I_Q = I_G$
(D) $I_Q = I_R$



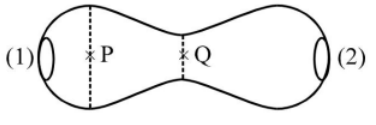
Q2. If the length of the filament of a heater is reduced by 10%, the power of the heater will
(A) increase by about 9%
(B) increase by about 11%
(C) increase by about 19%
(D) decrease by about 10%

Q3. The value of the resistance R in figure is adjusted such that power dissipated in the 2Ω resistor is maximum. Under this condition-



(A) R = 0
(B) R = 8Ω
(C) power dissipated in the 2Ω resistors is 72W
(D) power dissipated in the 2Ω resistor is 8W

Q4. A metallic conductor of irregular cross-section is as shown in the figure. A constant potential difference is applied across the ends (1) and (2). Then :



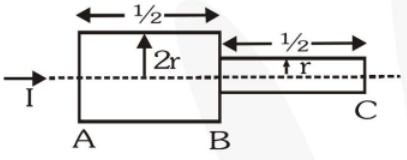
(A) the current at the cross-section P equals the current at the cross-section Q

(B) the electric field intensity at P is less than that at Q.

(C) the rate of heat generated per unit time at Q is greater than that at P

(D) the number of electrons crossing per unit area of cross-section at P is less than that at Q.

Q5. Two bars of radius r and 2r are kept in contact as shown. An electric current I is passed through the bars. Which one of following is correct :-



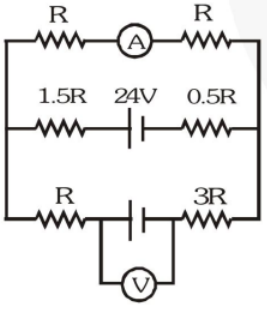
(A) Heat produced in bar BC is 4 times the heat produced in bar AB

(B) Electric field in both halves is equal

(C) Current density across AB is double that of across BC

(D) Potential difference across AB is 4 times that of across BC

Q6. If the reading of ammeter is 2A then the reading of voltmeter.



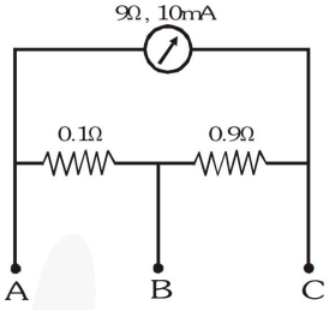
(A) Depends on R

(B) Independent on R

(C) Zero for certain value of R

(D) can't be determined

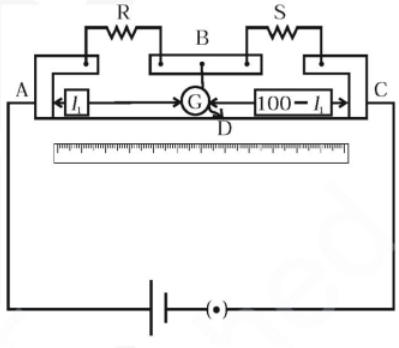
Q7. A milliammeter of range 10mA and resistance 9Ω is joined in a circuit as shown. The metre gives full–scale deflection for current I when A and B are used as its terminals, i.e., current enters at A and leaves at B (C is left isolated). The value of I is



(A) 100 mA (B) 900 mA

(C) 1A (D) 1.1 A

Q8. In a meter bridge the point D is a neutral point.



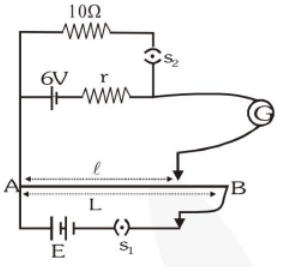
(A) The meter bridge can have no other neutral point for this set of resistances.

(B) When the jockey contacts a point on meter wire left of D, current flows to B from the wire through galvanometer.

(C) When the jockey contacts a point on the meter wire to the right of D, current flows from B to the wire through galvanometer.

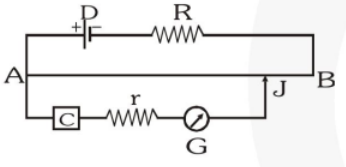
(D) When R is increased, the neutral point shifts to left.

Q9. In the arrangement shown in figure when the switch S_2 is open, the galvanometer shows no deflection for $\ell = \frac{L}{2}$. When the switch S_2 is closed, the galvanometer shows no deflection for $\ell = \frac{5L}{12}$. The internal resistance (r) of 6V cell, and the emf E of the other battery are respectively.



(A) 3Ω, 8V (B) 2Ω, 12V
(C) 2Ω, 24V (D) 3Ω, 12V

Q10. In the given potentiometer circuit, the resistance of the potentiometer wire AB is R_0. C is a cell of internal resistance r. The galvanometer G does not give zero deflection for any position of the jockey J. Which of the following cannot be a reason for this?



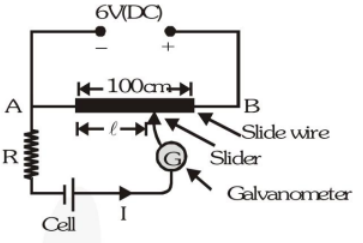
(A) $r > R_0$
(B) $R >> R_0$
(C) Emf of C> emf of D
(D) The negative terminal of C is connected to A

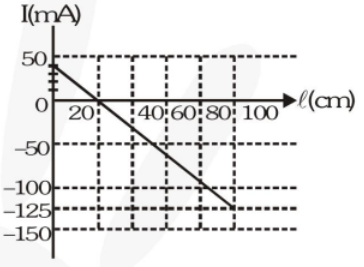
PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 11 to 13

In the circuit shown, the internal resistance of the cell is negligible. The distance of the jockey (slider) from left hand end of the wire is ℓ. The adjoining graph shows the variation of current I (marked in figure) with length ℓ of the slide wire.





Q11. For balancing condition of the instrument value of ℓ is equal to-
(A) 40 cm (B) 20 cm
(C) 100 cm (D) None of these

Q12. Value of the emf of cell, is-
(A) 0.98 V (B) 1.20 V
(C) 1.86 V (D) 3 V

Q13. Value of the resistance R, is-
(A) 30 Ω (B) 40 Ω
(C) 38 Ω (D) 45 Ω

Paragraph for Question No. 14 to 16

Important aspect of fuse wire and battery

Electric fuse a protective device used in series with an electric circuit or an electric appliance to save it from damage due to overheating produced by strong current in the circuit or appliance. Fuse wire

is generally made from an alloy of lead and tin which has high resistance and low melting point. It is connected in series in an electric installation. If a circuit gets accidentally short–circuited, a large current flows, then fuse wire melts away which causes a break in the circuit.

The power through fuse (P) is equal to heat energy lost per unit area per unit time (h) (neglecting heat loses from ends of the wire).

$$P = I^2R = h \times 2\pi r\ell \ .....\left[R = \frac{\rho\ell}{\pi r^2}\right]$$

r and ℓ are the length and radius of fuse wire. A battery is described by it's Emf (E) and internal resistance (r) Efficiency of battery is defined as the ratio of the output power and the input power

$$\eta = \frac{\text{output power}}{\text{input power}} \times 100\,\%$$

but $I = \frac{E}{R+r}$,

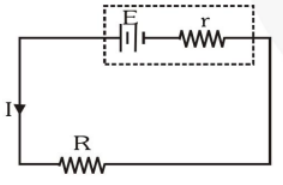
input power = EI ,

output power = $EI - I^2r$,

then $$\eta = \left(\frac{EI - I^2r}{EI}\right) \times 100 = \left(1 - \frac{Ir}{E}\right) \times 100$$

$$= 1 - \left(\frac{E}{R+r}\right)\left(\frac{r}{E}\right) \times 100 = \left(\frac{R}{R+r}\right) \times 100$$

We know that output power of a source is maximum when the external resistance is equal to internal resistance, i.e., R = r.



14. Two fuse wire of same material are having length ratio 1 : 2 and radius ratio 4 : 1. Then respective ratio of their current rating will be –

(A) 8 : 1 (B) 2 : 1

(C) 1 : 8 (D) 4 : 1

15. The maximum power rating of a 20.0 Ω fuse wire is 2.0 kW, then this fuse wire can be connected safely to a D.C. source (negligible internal resistance) of–

(A) 300 volt (B) 190 volt

(C) 250 volt (D) 220 volt

16. Efficiency of a battery (non–ideal) when delivering maximum power is–

(A) 100 % (B) 50 %

(C) 90 % (D) 40 %

Paragraph for Question No. 17 to 21

Ram and Shyam purchased two electric tea kettles 'A' and 'B' of same size, same thickness and same volume of 0.4 litre. They studied the specification of kettles as under.

Kettle – A	**Kettle – B**
Specific heat capacity = 1680 J/kg–K	Specific heat capacity = 2520 J/kg–K
mass = 200 gm	mass = 400 gm
cost = 400 Rs.	cost = 400 Rs.

When kettle 'A' is switched on with constant source, the tea begins to boil in 6 minute. When kettle 'B' is switched on with the same source separately then tea begins to boil in 8 minute.

The efficiency of kettle is defined as

$$= \frac{\text{energy used for liquid heating}}{\text{total energy supplied}}.$$

They made discussion on specification and efficiency of kettles and subsequently prepared a list of questions to draw the conclusions. Some of them are as under – (Assume specific heat of tea liquid as 4200 J/Kg–K and density as 1000 kg/m^3)

17. Efficiency of kettle 'A' is–

(A) 63.34 % (B) 83.33 %

(C) 93.34 % (D) 73.34 %

18. Efficiency of kettle 'B' is–

(A) 82.5 % (B) 72.5 %

(C) 92.5 % (D) 62.5 %

19. Ratio of electricity consumed charges for one time boiling of tea in kettle A and kettle B.

(A) 3 : 5 (B) 2 : 3

(C) 3 : 4 (D) 1 : 1

20. The resistance of coil of kettles A and B are 'R_A' and 'R_B' respectively, then we can say-

(A) $R_A > R_B$

(B) $R_A = R_B$

(C) $R_A < R_B$

(D) can not be ascertained by above data.

21. If both the kettles are joined with the same source in series one after the other. Then boiling starts in kettle 'A' and kettle 'B' after-

(A) 4 times of their original time

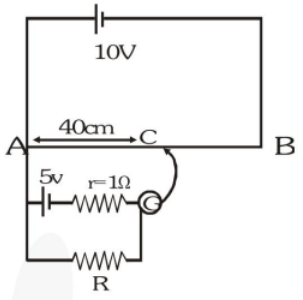
(B) equal to their original time

(C) 2 times of their original time

(D) can not be ascertained by above data

SUBJECTIVE TYPE

Q22. A potentiometer wire AB is 100 cm long and has a total resistance of 10 ohm. if the galvanometer shows zero deflection at the position C, then find the value of unknown resistance R.



Q23. Draw the circuit for experimental verification of Ohm's law using a source of variable DC voltage, a main resistance of 100 Ω, two galvanometers and two resistances of values 10^6 Ω and 10^{-3} Ω respectively. Clearly show the positions of the voltmeter and the ammeter.

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	B	C	C	C	D	B	D	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
D	B	B	D	B	B	D	C	B	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
C	C	A	A	A	C	B	A	B	C
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
B	D	D	A	D	B	B	B	B	B
41									
C									

Ex-1A

1. A **2.** A,C **3.** A,C **4.** A,C **5.** B,D

6. A,B **7.** A → (Q) ; B → (P); C → (P) **8.** 2 V; 0.4W

9. 3.7 A **10.** I = 0.5A, anticlockwise E_1= 4.25V, E_2 = 7.5V

11. 1V **12.** 10^{-3} A **13.** R = $4 \times 10^{-4}\ \Omega$ **14.** 32 V

15. $R_{AC} = \left(\frac{n^2+1}{n}\right) r$ **16.** $R_{sh} \approx 10^{-3}\ \Omega$

Ex-2

1	2	3	4	5	6	7	8	9	10
A	B	D	D	B	D	A	B	A	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	A	B	C	C	C	B	A	A	B
21	**22**								
A	B								

Ex-2A

1. A **2.** B **3.** A,C **4.** A,B,C,D **5.** A

6. A,C **7.** C **8.** A,B,C **9.** B **10.** A

11. B **12.** B **13.** A **14.** A **15.** B

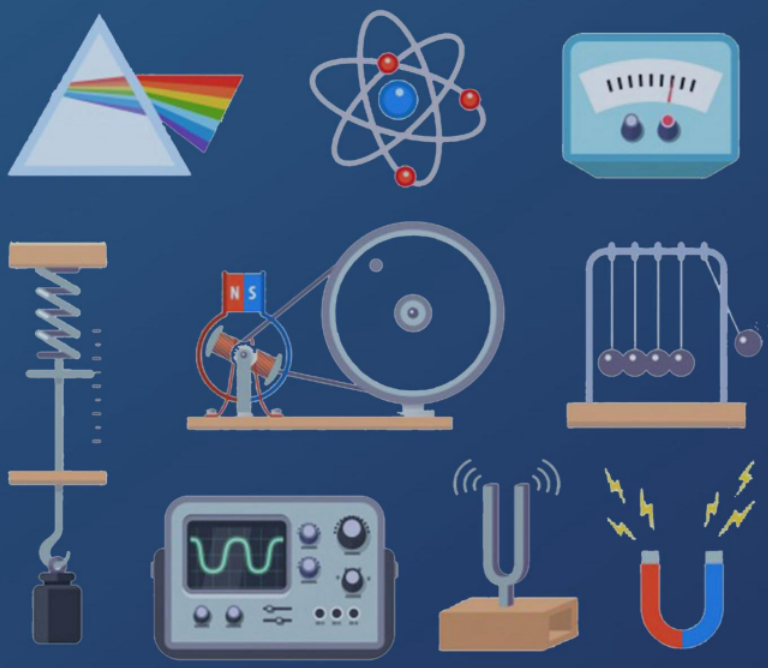
16. B **17.** B **18.** D **19.** C **20.** B

21. A **22.** 4 W

-: Important Notes & Formulas :-

PHYSICS

Dual Nature of Radiation & Matter



SHEET

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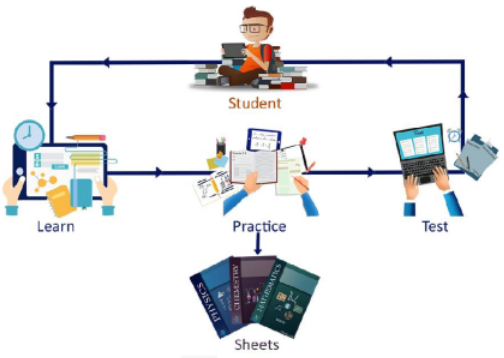
7.	Answer Key	Page - 11

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Phtotelectric Effect and Einstein's Equation	1-8	1-5,8-12	1-9	1-7,8-13, 17-23
2	Wave nature of Matter - De Broglie Wavelength	9-17	6-13	10-15	14-16,24
3	After Full Chapter		7	16	

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Photoelectric Effect and Einstein's Equation

Q1. Who discovered photo electric effect ?

(A) Hertz (B) Lenard

(C) Hallwach (D) Einstein

Q2. The wavelength of X-ray photon is 0.01 Å, its momentum in kg m/s is -

(A) 6.6×10^{-22} (B) 6.6×10^{-32}

(C) 6.6×10^{-46} (D) 6.6×10^{-27}

Q3. The work- function of a substance is 4.0 eV. The longest wavelength of light that can cause photoelectron emission from this substance is approximately :

(A) 540 nm (B) 400 nm

(C) 310 nm (D) 220 nm

Q4. When light of wavelength lesser than 6000 Å is incident on a metal, electrons are emitted. The approximate work-function of the metal is :

(A) 1 eV (B) 2 eV

(C) 4 eV (D) 6 eV

Q5. The maximum wavelength of light for photoelectric effect from a metal is 200 nm. The maximum kinetic energy of electron which is emitted by the radiation of wave length 100 nm will be :

(A) 12.4 eV (B) 6.2 eV

(C) 100 eV (D) 200 eV

Q6. If n_r and n_b are respectively, the number of photons emitted by a red bulb and a blue bulb of equal power in a given time, then

(A) $n_r = n_b$

(B) $n_r < n_b$

(C) $n_r > n_b$

(D) nothing can be predicted

Q7. **Statement 1** : Photoelectric effect establishes quantum nature of light.

Statement 2 : There is negligible time lag between photon collisions with the material and photoelectron emission irrespective of intensity of incident light. (Assume incident light is of frequency greater than threshold frequency of the material).

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

Q8. Two monochromatic light sources. A and B emit the same number of photons per second. The wavelength of A is $\lambda_A = 400$ nm and that of B is $\lambda_B = 600$ nm. The power radiated by source B is -

(A) Equal to that of source A.

(B) Less than that of source A.

(C) Greater than that of source A.

(D) Cannot be compared to that from source A using the available data.

Wave Nature of Matter-De Broglie wavelength

Q9. Electron has energy of 100 eV. What will be its wavelength –

(A) 1.2 Å (B) 10 Å

(C) 100 Å (D) 1 Å

Q10. An electron is moving with velocity 6.6 x 10^3 m/s. The De-Broglie wavelength associated with electron is
(mass of electron = 9×10^{-31} Kg,
Planck's Constant = 6.62×10^{-34} J-s)
(A) 1×10^{-19} m
(B) 1×10^{-5} m
(C) 1×10^{-7} m
(D) 1×10^{-10} m

Q11. The de Broglie wavelength associated with a ball of mass 1 kg having kinetic energy 0.5 J is ?
(A) 6.626×10^{-32} cm
(B) 5.257×10^{-36} cm
(C) 6.297×10^{-36} cm
(D) 7.287×10^{-36} cm

Q12. The De-Broglie wavelength associated with electrons revolving round the nucleus in a hydrogen atom in ground state, will be :
(A) 0.3 Å (B) 3.3 Å
(C) 6.62 Å (D) 10 Å

Q13. A proton moves on a circular path of radius 6.6×10^{-3} m in a perpendicular magnetic field of 0.625 tesla. The De broglie wavlength associated with the proton will be :
(A) 1Å (B) 0.1Å
(C) 0.01Å (D) 0.001Å

Q14. de Broglie equation for an electron shows its -
(A) particle nature
(B) wave nature
(C) dual nature
(D) none of these

Q15. What is the de broglie wavelength in (Å) of the α-particle accelerated through a potential difference V.
(A) $\frac{0.287}{\sqrt{V}}$ (B) $\frac{12.27}{\sqrt{V}}$
(C) $\frac{0.101}{\sqrt{V}}$ (D) $\frac{0.22}{\sqrt{V}}$

Q16. Linear momenta of a proton and an electron are equal. Relative to an electron-
(A) Kinetic energy of proton is more.
(B) de-Broglie wavelength of proton is more.
(C) de-Broglie wavelength of proton is less.
(D) de-Broglie wavelength of proton and electron are equal.

Q17. A proton and an α - particle accelerated through same voltage. The ratio of their De-broglie wavelength will be :
(A) 1 : 2 (B) $2\sqrt{2}$:1
(C) $\sqrt{2}$:1 (D) 2 : 1

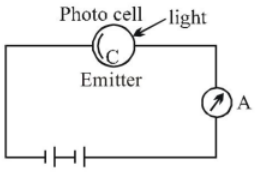
Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The stopping potential for photo electron emitted from a metal surface of work function 1.7 eV is 10.4V. Select correct choice
(A) The wavelength of light used is 1024 Å
(B) The wavelength of light used is 970.6 Å
(C) The light used may be emitted by hydrogen gas sample which de–excites from n=3 to n=1
(D) The light used may be emitted by hydrogen gas sample which de–excites from n = 2 to n = 1

Q2. The figure shows a photo cell circuit. The cathode of the photo cell is illuminated by a monochromatic light. If the intensity is kept constant and the frequency of the incident light is increased, then the



(A) Photo electric current in the circuit increases.

(B) Saturation electric current in the circuit decreases.

(C) Maximum kinetic energy of the photo electrons increases.

(D) Photo electric current in the circuit can be reduced to zero.

when the polarity of the terminals is reversed.

Q3. In a photoelectric experiment, with light of wavelength λ, the fastest electron has speed v. If the wavelength is changed to $\frac{3\lambda}{4}$, the speed of the fastest emitted electron will becomes

(A) $v\sqrt{\frac{3}{4}}$

(B) $v\sqrt{\frac{4}{3}}$

(C) less than $v\sqrt{\frac{3}{4}}$

(D) greater than $v\sqrt{\frac{4}{3}}$

Q4. Photoelectric effect supports quantum nature of light because :

(A) There is a minimum frequency below which no photoelectrons are emitted.

(B) The maximum kinetic energy of photo-electrons depends only on the frequency of light and not on its intensity.

(C) Even when the metal surface is faintly illuminated the photoelectrons if any of them leave the surface immediately.

(D) Electric charge of the photoelectrons is quantized.

Q5. In photoelectric effect, stopping potential depends on -

(A) frequency of the incident light

(B) intensity of the incident light by varies source distance

(C) emitter's properties

(D) frequency and intensity of the incident light

Q6. If particles are moving with same velocity, then maximum de-Broglie wavelength will be for-

(A) proton

(B) α - particle

(C) neutron

(D) β - particle

Q7. Which of the following phenomena can be explained only on the basis of quantum theory of light?

(A) Energy spectrum of black body radiation

(B) Atomic spectra

(C) Photoelectric effect

(D) Doppler effect

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q8. Some quantities related to the photoelectric effect are mentioned under Column I and Column II. Match each quantity in Column I with the corresponding quantities in Column II on which it depends

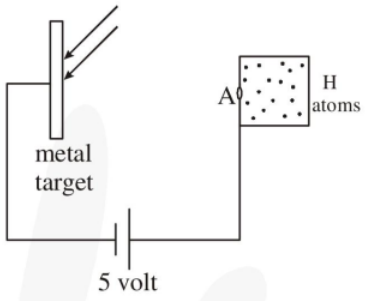
Column-I	Column-II
(A) Saturation current	(P) Frequency of light
(B) Stopping potential	(Q) Work function
(C) de-Broglie wavelength of photoelectron	(R) Area of photosensitive plate
(D) Force due to radiation falling on the photo–plate.	(S) Intensity of light (at constant frequency)
	(T) None of these

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q9. If light of wavelength 4000 Å falls on a metal which has a stopping potential 1·4 volt against photoelectric emission then what is the work function of the metal. [Take $h = 6{\cdot}6 \times 10^{-34}$ Js and $c = 3 \times 10^{8}$ ms^{-1}] (in ev).

Q10. Electromagnetic waves of wavelength 1242 Å are incident on a metal of work function 2eV. The target metal is connected to a 5 volt cell, as shown. The electrons pass through hole A into a gas of hydrogen atoms in their ground state. Find the number of spectral lines emitted when hydrogen atoms come back to their ground states after having been excited by the electrons. Assume all excitations in H-atoms from ground state only. (hc = 12420 eVÅ)



SUBJECTIVE TYPE

Q11. The work function of a metal is 4 eV. If 5000Å wavelength of light is incident on the metal, is there any photo electric effect?

Q12. A TV station is operated at 100 MW with a signal frequency of 10 MHz. Calculate the number of photons radiated per second by its antenna.

Q13. A particle of mass M at rest explodes into two particles of masses m_1 and m_2 having non zero velocities. Find out the ratio of the de–Broglie wavelengths of the two particles.

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. The number of photons emitted in one second by a 100 watt red light source, assuming for simplicity the average wavelength for each photon is 694 nm is-

(A) 3.49×10^{20} (B) 4.49×10^{20}

(C) 3.49×10^{18} (D) 4.49×10^{18}

Q2. Which one of the following is true in photoelectric emission-

(A) Photoelectric current is directly proportional to the amplitude of light of a given frequency.

(B) Photoelectric current is directly proportional to the intensity of light of a given frequency above threshold value.

(C) Above the threshold frequency, the maximum K.E. of photoelectrons is inversely proportional to the frequency of incident light.

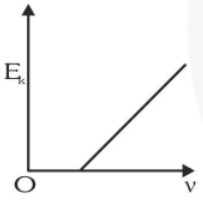
(D) The threshold frequency depends upon the wavelength of incident light.

Q3. The work functions of tungsten and sodium are 5.06 eV and 2.53 eV respectively. If the threshold wavelength for sodium is 5896 Å, then the threshold wavelength for the tungsten will be :

(A) 11792 Å (B) 5896 Å

(C) 4312 Å (D) 2948 Å

Q4. Graph is plotted between maximum kinetic energy of electron with frequency of incident photon in Photo electric effect. The slope of curve will be-



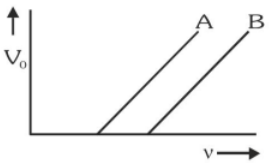
(A) charge of electron

(B) work function of metal

(C) planck's constant

(D) ratio of Planck constant and charge of electron

Q5. The stopping potential as a function of frequency of incident radiation is plotted for two different surfaces A and B. The graphs show that the work function of A is-



(A) Greater than that of B

(B) Smaller than that of B

(C) Same as that of B

(D) No comparison can be done from given graphs

Q6. The work functions for metals A, B and C are respectively 1.92 eV, 2.0 eV and 5 eV. According to Einstein's equation, the metals which will emit photo electrons for a radiation of wavelength 4100 Å is /are-

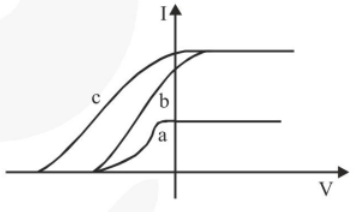
(A) none

(B) A only

(C) A and B only

(D) all the three metals.

Q7. The figure shows the variation of photocurrent with anode potential for a photosensitive surface for three different radiations. Let I_a, I_b and I_c be the intensities and f_a, f_b and f_c be the frequencies for the curves a, b and c respectively :



(A) $f_a = f_b$ and $I_a \neq I_b$

(B) $f_a = f_c$ and $I_a = I_c$

(C) $f_a = f_b$ and $I_a = I_b$

(D) $f_b = f_c$ and $I_b = I_c$

Q8. The threshold frequency for a certain metal is 3.3×10^{14} Hz. If light of frequency 8.2×10^{14} Hz is incident on the metal, the cutoff voltage for the photoelectric emission is.

(A) 8 V (B) 6 V

(C) 2 V (D) 4 V

Q9. Light coming from a discharge tube filled with hydrogen falls on the cathode of the photoelectric cell. The work function of the surface of cathode is 4eV. Which one of the following values of the anode voltage (in Volts) with respect to the cathode will likely to make the photo current zero?

(A) – 4 (B) – 6

(C) – 8 (D) – 10

Q10. Two particles have identical charges. If they are accelerated through identical potential differences, then the ratio of their deBroglie wavelengths would be :

(A) $\lambda_1 : \lambda_2 = 1 : 1$

(B) $\lambda_1 : \lambda_2 = m_2 : m_1$

(C) $\lambda_1 : \lambda_2 = \sqrt{m_2} : \sqrt{m_1}$

(D) $\lambda_1 : \lambda_2 = \sqrt{m_1} : \sqrt{m_2}$

Q11. The energy that should be added to an electron to reduce its De broglie wavelength from 10^{-10}m to 0.5×10^{-10} m will be :

(A) Four times the initial energy

(B) Equal to initial energy

(C) Twice the initial energy

(D) Thrice the initial energy

Q12. If the mass of neutron = 1.7×10^{-27} kg. then the De broglie wavelength of neutron of energy 3eV is :

(A) 1.6×10^{-10} m

(B) 1.6×10^{-11} m

(C) 1.4×10^{-10} m

(D) 1.4×10^{-11} m

Q13. A proton and an α–particle have kinetic energy in the ratio 16:1. The ratio of de-Broglie wavelength associated with them is:-

(A) 4 : 1 (B) 2 : 1

(C) 1 : 2 (D) 7 : 2

Q14. The mass of a particle is m. If its kinetic energy is increased to four times, then de-Broglie wavelength will :

(A) Remain unchanged

(B) Become half

(C) Become double

(D) Become $\frac{1}{\sqrt{2}}$ times.

Q15. The energy of a photon is equal to the kinetic energy of a proton. The energy of the photon is E. Let λ_1 be the de–Broglie wavelength of the proton and λ_2 be the wavelength of the photon. The ratio λ_1/λ_2 is proportional to :-

(A) E° (B) $E^{1/2}$

(C) E^{-1} (D) E^{-2}

Q16. A neutron having kinetic energy 13.6 eV collides with a hydrogen atom in ground state at rest. Assume that the mass of neutron and hydrogen atoms are same and the neutron does not leave its line of motion. Then which of the following is the possible KE of the neutron after the collision?

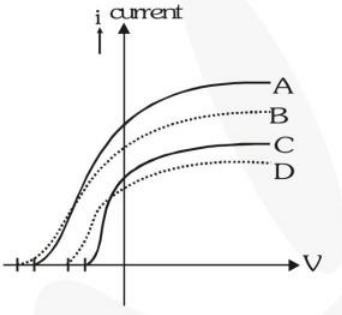
(A) zero (B) 3.4 eV

(C) 1.5 eV (D) 6.8 eV.

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The figure shows the results of an experiment involving photoelectric effect. The graphs A, B, C and D relate to a light beam having different wavelengths. Select the correct alternative.



(A) Beam B has highest frequency

(B) Beam C has longest wavelength

(C) Beam A has highest rate of photoelectric emission

(D) Photoelectrons emitted by B have highest momentum

Q2. In a photoelectric experiment, the collector plate is at 2.0V with respect to the emitter plate made of copper (ϕ= 4.5 eV). The emitter is illuminated by a source of monochromatic light of wavelength 200 nm.

(A) The minimum kinetic energy of the photoelectrons reaching the collector is 0.

(B) The maximum kinetic energy of the photoelectrons reaching the collector is 3.7 eV.

(C) If the polarity of the battery is reversed then answer to part A will be 0

(D) If the polarity of the battery is reversed then answer to part B will be 1.7 eV

Q3. Cut off potential for a metal in photoelectric effect for light of wavelength λ_1, λ_2 and λ_3 is found to be V_1, V_2 and V_3 volts if V_1, V_2 and V_3 are in Arithmetic Progression and λ_1, λ_2 and λ_3 will be :

(A) Arithmetic Progression

(B) Geometric progression

(C) Harmonic Progression

(D) None

Q4. In a photoelectric effect experiment, if f is the frequency of radiations incident on the metal surface and I is the intensity of the incident radiations, then choose the correct statement(s).

(A) If f is increased keeping I and work function constant then maximum kinetic energy of photoelectron increases.

(B) If distance between cathode and anode is increased stopping potential increases.

(C) If I is increased keeping f and work function constant then stopping potential remains same and saturation current increases.

(D) Work function is decreased keeping f and I constant then stopping potential increases.

Q5. The collector of the photocell (in photo-electric experiment) is made of tungsten while the emitter is of Platinum having work function of 10 eV. Monochromatic radiation of wavelength 124 Å & power 100 watt is incident on emitter which emits photo electrons with a quantum efficiency of 1%. The accelerating voltage across the photocell is of 10,000 volts (Use : hc = 12400eV Å)

(A) The power supplied by the accelerating voltage source is 100 watt

(B) The minimum wavelength of radiation coming from the tungsten target (collector) is 1.23 Å

(C) The power supplied by the accelerating voltage source is 10 watt

(D) The minimum wavelength of radiation coming from the tungsten target (collector) is 2.23 Å

Q6. Light of wavelength λ_1 & λ_2 are falling on two metal surface A & B. For wavelength λ_1 electron ejected from both the surfaces and for wavelength λ_2 electron ejected from only surface B. On the basis of these facts which of the following is/are false statement (s).

(A) more energy is required for ejection of electron from metal 'A'

(B) $\lambda_1 > \lambda_2$

(C) threshold wavelength for A is greater than B

(D) energy of electron ejected from metal A will be greater than electron ejected from metal B for a given wavelength λ

Q7. The accelerating potential (V) applied between a photocathode and the respective anode is such that the fastest photoelectron can fly only one fourth of the distance between the cathode and the anode. If the distance between photocathode and anode is reduced to $(1/4)^{th}$ of the original value while maintaining the accelerating potential constant, then -

(A) The fastest electron will reach the anode.

(B) The fastest electron will reach upto one fourth of the new distance between the cathode and the anode.

(C) Kinetic energy of the fastest photo-electron emitted from photocathode will not change due to change in plate separation (keeping V constant).

(D) Kinetic energy of the fastest photo-electron will increase due to decrease in plate separation (keeping V constant).

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No 8 to 10

A mercury arc lamp provides 0.1 watt of ultra-violet radiation at a wavelength of λ = 2537 Å only. The photo tube (cathode of photo electric device) consists of potassium and has an effective area of 4 cm^2. The cathode is located at a distance of 1m from the radiation source. The work function for potassium is ϕ_0 = 2.22 eV.

Q8. According to classical theory, the radiation from arc lamp spreads out uniformly in space as spherical wave. What time of exposure to the radiation should be required for a potassium atom (radius 2Å) in the cathode to accumulate sufficient energy to eject a photo-electron ?

(A) 352 second (B) 176 second

(C) 704 seconds (D) No time lag

Q9. To what saturation current does the flux of photons at the cathode corresponds if the photo conversion efficiency is 5%.

(A) 32.5 nA (B) 10.15 nA

(C) 65 nA (D) 3.25 nA

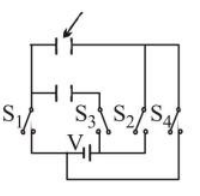
Q10. What is the cut off potential V_0 ?

(A) 26.9 V (B) 2.69 V

(C) 1.35 V (D) 5.33 V

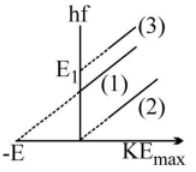
Paragraph for Question No 11 to 13

The circuit shown is placed in vacuum. Both the capacitors are identical and they have the same capacitance C. Light is incident on the left plate of the upper capacitor. When all the switches are open then the hf versus KE_{max} is shown by the straight line (1). In all the cases, we are measuring the KE_{max} when the electron reaches the opposite plate.



When only S_1 the switches and S_2 are closed, the graph becomes (2).

When only S_3 and S_4 are closed then the graph becomes (3).



Q11. What is the work function of the cathode?

(A) E (B) E_1

(C) $E + E_1$ (D) none of these

Q12. What is the value of eV ?

(A) E (B) E_1

(C) $E + E_1$ (D) none of these

Q13. What is the value of E_1?

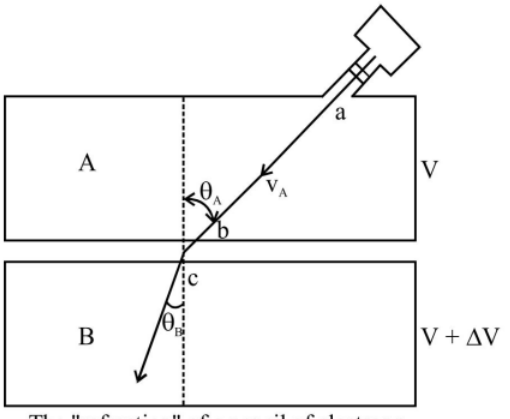
(A) 3E (B) 3E/2

(C) E/2 (D) none of these

Paragraph for Question No 14 to 16

Let a pencil of electrons from a suitable gun G enter through orifice in an enclosed metal box A, which has potential V relative to filament of the gun. Let these electrons emerge from A through orifice b and enter through c to another box B, which is maintained at a potential V + ΔV. The electric field between the two boxes changes the component of velocity of the electrons perpendicular to the adjacent surface, and the electrons enter B with a change in their direction of motion. Let v_A and v_B be the velocities of the electrons in A and B, respectively, and θ_A, θ_B the angles between these directions and the normal to the box faces at b and c. Since the electric field does not change the horizontal component of velocity, $v_A \sin\theta_A = v_B \sin\theta_B$,

$\frac{\sin\theta_A}{\sin\theta_B} = \frac{v_B}{v_A}$.



The "refraction" of a pencil of electrons

Now if we dealing with light waves undergoing refraction, or any other kind of wave, the relation would be :

$$\frac{\sin\theta_A}{\sin\theta_B} = \mu = \frac{u_A}{u_B}$$

where μ is the relative refractive index of the two media and u_A, u_B are the corresponding velocities of light wave. Comparison of the last two equations gives the result $\frac{u_A}{u_B} = \frac{v_B}{v_A}$. We may conclude that if matter waves follow the electron along its path, the wave speed u is inversely proportional to the speed v of the electron, or $u = \frac{b}{v}$.

Q14. If we define the frequency of matter waves as $f = \frac{u}{\lambda}$, the -

(A) Frequency of matter waves in medium A is more than that in medium B

(B) Frequency of matter waves in medium A is less than that in medium B

(C) Frequency of matter waves in medium A is same as that in medium B

(D) Cannot be predicted

Q15. Suppose $V_A = 20$ volt and $V_B = 15$ volt. Choose the **CORRECT** statement :-

(A) The speed of electrons as well as speed of matter waves inside box B is more

(B) The speed of electrons as well as speed of matter waves inside box B is less

(C) The speed of electrons inside the box B is more, but speed of matter waves in box B is less

(D) The speed of electrons inside the box B is less, but speed of matter waves in box B is more

Q16. The refractive index for matter waves can be defined as $\frac{c}{u}$ where c is some constant. So refractive index for matter waves

(A) is inversely proportional to λ

(B) is independent of λ

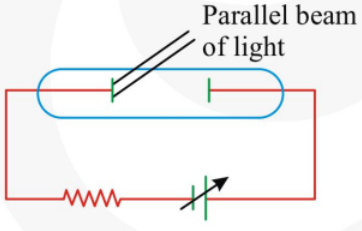
(C) is directly proportional of λ

(D) is proportional to $\sqrt{\lambda}$

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q17. In the shown experimental setup to study photoelectric effect, two conducting electrodes are enclosed in an evacuated glass-tube as shown. A parallel beam of monochromatic light, falls on photosensitive electrodes. The emf of battery shown is high enough such that all photoelectrons ejected from left electrode will reach the right electrode. Under initial conditions photoelectrons are emitted. As changes are made in each situation of column I; Match the statements in column I with results in column II.



Column I	**Column II**
(A) If frequency of incident light is increased keeping its intensity constant	(P) magnitude of stopping potential will increase
(B) If frequency of incident light is increased and its intensity is decreased	(Q) current through circuit may stop
(C) If work function of photo sensitive Electrode is increased	(R) maximum kinetic energy of ejected photoelectrons will increase
(D) If intensity of incident light is increased Keeping its frequency constant	(S) saturation current will increase

NUMERICAL TYPE

Q18. Threshold frequency of a surface is ν_0. It is illuminated by $3\nu_0$ frequency, then maximum speed of photo electrons is V m/sec. If incident frequency is $9\nu_0$, maximum speed is NV. Find N ?

Q19. When incident wavelength is λ, stopping potential is $3V_0$. If incident wavelength is 2λ then stopping potential is V_0. Threshold wavelength is $N\lambda$. Find N

Q20. In a photoelectric setup, the radiations from the Balmer series of hydrogen atom are incident on a metal surface of work function 2eV. The wavelength of incident radiations lies between 450 nm to 700 nm. Find the maximum kinetic energy of photoelectron emitted.
(Given hc/e = 1242 eV-nm).

SUBJECTIVE TYPE

Q21. A parallel beam of monochromatic light of wave length 500 nm is incident normally on a perfectly absorbing surface. The power through any cross-section of the beam is 10 W.
Find :
(a) Number of photon absorbed by the surface per second.
(b) The force exerted by light beam on the surface.

Q22. Calculate number of photons passing through a ring of unit area in unit time if light of intensity 100 Wm^{-2} and of wavelength 400 nm is falling normally on the ring.

Q23. A monochromatic light incident on metal 'A' having threshold frequency ν_0. It emits photo electrons of maximum kinetic energy K. Now incident frequency is made three times and fall on a metal 'B' having threshold frequency $2\nu_0$. What will be the maximum kinetic energy of photo electrons emitted by metal 'B' ?

Q24. A particle moving with velocity that is three times that of velocity of electron. If ratio of de-Broglie wave length of particle to that of the electron is 1.8×10^{-4}.
Find mass of particle ($m_e = 9.1 \times 10^{-31}$ kg)

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	A	C	B	B	C	A	B	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**			
A	B	C	C	C	D	B			

Ex-1A

1. A,C **2.** B,C,D **3.** D **4.** A,B,C **5.** A,C

6. D **7.** A,B,C **8.** (A) R,S (B) P,Q (C) P,Q (D) R,S

9. 1.7 eV **10.** 6 **11.** No **12.** 1.5×10^{34} **13.** 1:1

Ex - 2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	B	D	C	B	C	A	C	D	C
11	**12**	**13**	**14**	**15**	**16**				
D	B	C	B	B	A				

Ex-2A

1. A,B,C,D **2.** B **3.** C **4.** A,C,D **5.** A,B

6. B,C,D **7.** B,C **8.** A **9.** A **10.** B

11. A **12.** A **13.** B **14.** C **15.** D

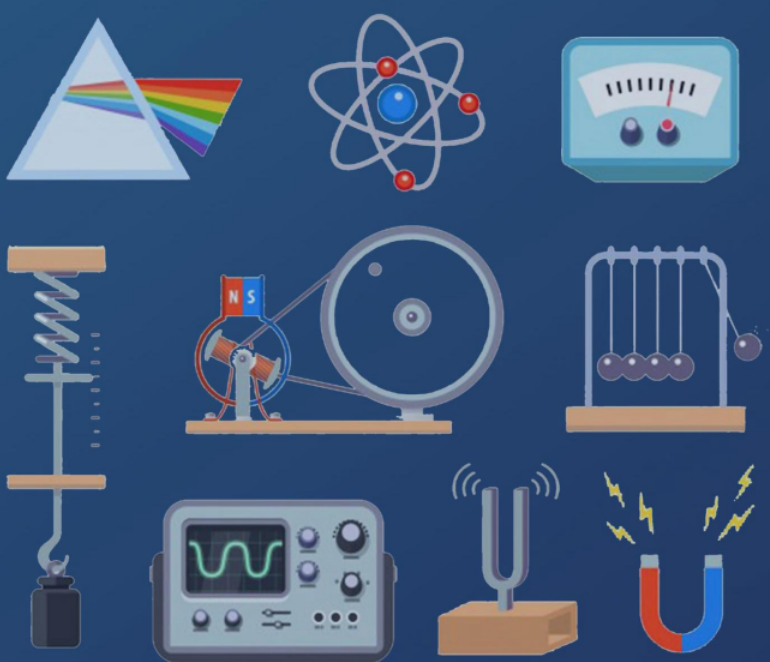
16. A **17.** (A)-P,R (B)-P,R (C)-Q (D)-S **18.** 2

19. 4 **20.** 0.55 eV 21. (a) 2.5×10^{19} (b) 3.33×10^{-7} N

22. 2.02×10^{20} **23.** $3K + h\nu_0$ 24. 1.68×10^{-27} kg

PHYSICS

Elasticity



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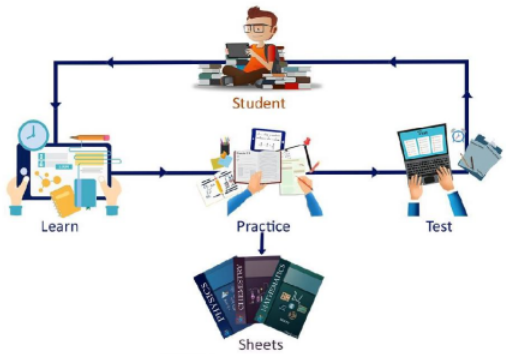
Note

Detailed solutions are available on the eSaral App.

Module Description



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"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

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Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

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Home Work Index

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Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Stress and Strain	1	1,4,6,7	1	1
2	Hooke's Law and Elastic Moduli	2-7	2,5	2-5	2-4
3	Stress-Strain Curve and Elastic Potential Energy	8,9	3		5,6

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Stress and Strain

Q1. One end of uniform wire of length L and of weight W is attached rigidly to a point in the roof and a weight W_1 is suspended from its lower end. If S is the area of cross-section of the wire, the stress in the wire at a height (L/4) from its lower end is

(A) $\frac{W_1}{S}$ (B) $\frac{\left[W_1+\frac{W}{4}\right]}{S}$

(C) $\frac{\left[W_1+\frac{3W}{4}\right]}{S}$ (D) $\frac{W_1+W}{4}$

Hooke's Law and Elastic Moduli

Q2. The bulk modulus of copper is 1.4×10^{11} Pa and the coefficient of linear expansion is $1.7 \times 10^{-5}\ (C°)^{-1}$. What hydrostatic pressure is necessary to prevent a copper block from expanding when its temperature is increased from 20°C to 30°C?

(A) 6.0×10^5 Pa (B) 7.1×10^7 Pa

(C) 5.2×10^6 Pa (D) 40 atm

Q3. The pressure of a medium is changed from 1.01×10^5 Pa to 1.165×10^5 Pa and change in volume is 10% keeping temperature constant. The bulk modulus of the medium is :–

(A) 204.8×10^5 Pa

(B) 102.4×10^5 Pa

(C) 51.2×10^5 Pa

(D) 1.55×10^5 Pa

Q4. A highly rigid cubical block A of small mass M and side L is fixed rigidly onto another cubical block B of same dimensions and of low modulus of rigidly η such that lower face of A completely covers the upper face of B. The lower face of B is rigidly held on a horizontal surface. A small force F is applied perpendicular to one of the side face of A. After the force is withdrawn, block A executes small oscillations, the time period of which is given by-

(A) $2\pi\sqrt{M\eta L}$ (B) $2\pi\sqrt{\frac{M}{\eta L}}$

(C) $2\pi\sqrt{\frac{ML}{\eta}}$ (D) $\sqrt{\frac{M\eta}{L}}$

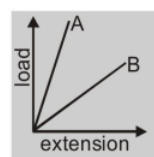
Q5. The dimensions of two wires A and B are the same. But their materials are different. Their load-extension graphs are shown. If Y_A and Y_B are the values of Young's modulus of elasticity of A and B respectively then -

(A) $Y_A > Y_B$

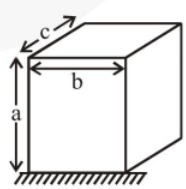
(B) $Y_A < Y_B$

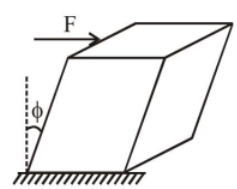
(C) $Y_A = Y_B$

(D) $Y_B = 2Y_A$



Q6. A cuboidal block of sides a, b & c is fixed on ground. The top is pushed by a horizontal force F as shown. The angle ϕ by which the block deforms is : (η is modulus of rigidity)





(A) $\frac{F}{ab\eta}$ (B) $\frac{F}{ac\eta}$

(C) $\frac{F}{bc\eta}$ (D) $\frac{F}{\sqrt{b^2+c^2}\,\eta}$

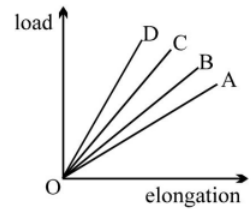
Q7. A force F is needed to break a copper wire having radius R. The force needed to break a copper wire of radius 2R will be :-

(A) $\frac{F}{2}$ (B) 2F

(C) 4F (D) $\frac{F}{4}$

Stress-Strain Curve and Elastic Potential Energy

Q8. The load versus strain graph for four wires of the same material is shown in the figure. The thickest wire is represented by the line:-



(A) OB (B) OA (C) OD (D) OC

Q9. Two wires of the same material and length but diameters in the ratio 1 : 2 are stretched by the same force. The potential energy per unit volume for the two wires when stretched will be in the ratio.

(A) 16 : 1 (B) 4 : 1

(C) 2 : 1 (D) 1 : 1

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A wire is suspended from the ceiling and stretched under the action of a weight *F* suspended from its other end. The force exerted by the ceiling on it is equal and opposite to the weight.

(A) Tensile stress at any cross section *A* of the wire is *F/A*.

(B) Tensile stress at any cross section is zero.

(C) Tensile stress at any cross section *A* of the wire is *2F/A*.

(D) Tension at any cross section A of the wire is *F*.

Q2. The temperature of a wire is doubled. The Young's modulus of elasticity

(A) will also double.

(B) will become four times.

(C) will remain same.

(D) will decrease.

Q3. A wire fixed at the upper end stretches by length ℓ by applying a force F. The work done in stretching is-

(A) $\frac{F}{2\ell}$ (B) $F\ell$

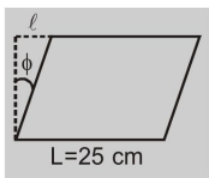
(C) $2F\ell$ (D) $\frac{F\ell}{2}$

NUMERICAL TYPE

The answer to each question is a ***NUMERICAL VALUE****. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

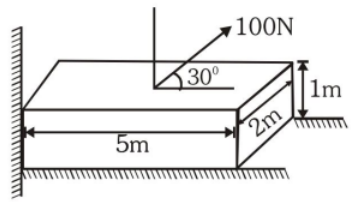
Q4. The breaking stress of steel is 7.9×10^8 N/m² and density is 7.9×10^3 kg/m³. What should be the maximum length so that it may not break with its own weight is .....km.

Q5. Two parallel and opposite forces, each 4000 N, are applied tangentially to the upper and lower faces of a cubical metal block of side 25 cm. If the shear modulus for the metal is 8×10^{10} Pa, then the displacement of the upper surface relative to the lower surface will be ..... m.



SUBJECTIVE TYPE

Q6. Find out longitudinal stress and tangential stress on a fixed block.



Q7. A human bone is subjected to a compressive force of 5.0×10^5 N. The bone is 25 cm long and has an approximate cross sectional area 4.0 cm². If the ultimate compressive strength of the bone is 1.70×10^8 N/m², will the bone be compressed or it will break under this force ?

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Steel ruptures when a shear of 3.5×10^8 Nm^{-2} is applied. The force needed to punch a 1 cm diameter hole in a steel sheet 0.3 cm thick is nearly :-

(A) 3.3×10^4 N (B) 1.4×10^4 N

(C) 1.1×10^4 N (D) 2.7×10^4 N

Q2. A solid sphere of radius R made of material of bulk modulus K is surrounded by a liquid in a cylindrical container. A massless piston of area A floats on the surface of the liquid. When a mass m is placed on the piston to compress the liquid, the fractional change in the radius of the sphere $\Delta R/R$ is

(A) mg/AK (B) mg/3AK

(C) mg/A (D) mg/3AR

Q3. A steel wire 1.5 m long and of radius 1 mm is attached with a load 3 kg at one end the other end of the wire is fixed, it is whirled in a vertical circle with a frequency 2Hz. Find the elongation of the wire when the weight is at the lowest position–

($Y = 2 \times 10^{11}$ N/m² and $g = 10$ m/s²)

(A) 1.77×10^{-3} m

(B) 7.17×10^{-3} m

(C) 3.17×10^{-7} m

(D) 1.37×10^{-7} m

Q4. The Young's modulus of a rubber string 8 cm long and density 1.5 kg/m³ is 5×10^8 N/m², is suspended on the ceiling in a room. The increase in length due to its own weight will be :

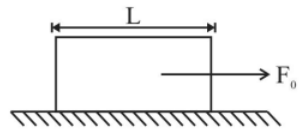
(A) 9.6×10^{-5} m

(B) 9.6×10^{-11} m

(C) 9.6×10^{-3} m

(D) 9.6 m

Q5. A constant force F_0 is applied on a uniform elastic string placed over a smooth horizontal surface as shown in figure. Young's modulus of string is Y and area of cross - section is S.The strain produced in the string in the direction of force is -



(A) $\frac{F_0 Y}{S}$ (B) $\frac{F_0}{SY}$ (C) $\frac{F_0}{2SY}$ (D) $\frac{F_0 Y}{2S}$

Exercise - 2A *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

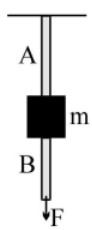
Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A copper and a steel wire of the same diameter are connected end to end. A deforming force F is applied to this composite wire which causes a total elongation of 1cm. The two wires will have

(A) the same stress. (B) different stress.

(C) the same strain. (D) different strain.

Q2. The wires A and B shown in the figure are made of the same material and have radii r_A and r_B respectively. The block between them has a mass m. When the force F is mg/3, one of the wires breaks.



(A) A breaks if $r_A = r_B$

(B) A breaks if $r_A < 2r_B$

(C) Either A or B may break if $r_A = 2r_B$

(D) The lengths of A and B must be known to predict which wire will break

Q3. Overall changes in volume and radii of a uniform cylindrical steel wire are 0.2% and 0.002% respectively when subjected to some suitable force. Longitudinal tensile stress acting on the wire is :-

($Y = 2.0 \times 10^{11}$ Nm^{-2})

(A) 3.2×10^9 Nm^{-2} (B) 3.2×10^7 Nm^{-2}

(C) 3.6×10^9 Nm^{-2} (D) 3.9×10^8 Nm^{-2}

Q4. A cylindrical wire of radius 1 mm, length 1 m, Young's modulus = 2×10^{11} N/m^2, poisson's ratio $\mu = \pi/10$ is stretched by a force of 100 N. Its radius will become :

(A) 0.99998 mm (B) 0.99999 mm

(C) 0.99997 mm (D) 0.99995 mm

NUMERICAL TYPE

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Q5. A wire suspended vertically from one of its ends is stretched by attaching a weight of 200 N to the lower ends. The weight stretches the wire by 1mm. Then the elastic energy stored in the wire is-

Q6. Young modulus of elasticity of brass is 10^{11} N/m^2. On pressing the rod of length 0.1 m and cross–sectional area 1 cm^2 made from brass with a force of 10 N along its length, the increase in its energy will be ..... J.

Answer Key

Ex-1								
1	2	3	4	5	6	7	8	9
B	B	D	B	A	C	C	C	A

Ex-1A

1. A,D **2.** D **3.** D

4. 10 **5.** 2×10^{-7}

6. $5\sqrt{3}$ N/m^2 , 5 N/m^2 **7.** Bone will break

Ex-2				
1	2	3	4	5
A	B	A	B	C

Ex-2A

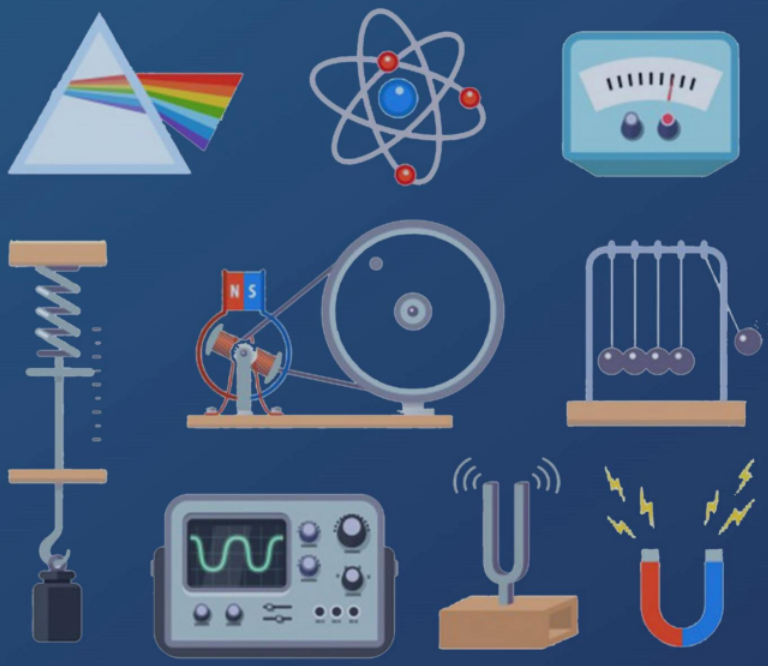
1. A,D **2.** A,B,C **3.** D

4. D **5.** 0.1 J **6.** 5×10^{-7}

-: Important Notes & Formulas :-

PHYSICS

Electromagnetic Induction (EMI)



SHEET

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Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	EMI - Introduction				
2	Magnetic Flux	1	17-19		
3	Faraday's Law of Induction	2-5	1	1	1
4	Lenz's Law	6-12	2-4,16, 20-22	2-5	8,9
5	Motional EMF	13-16	5,6, 13-15,23	6-10	2,13
6	Eddy Currents	17,18	7		
7	Induced Electric Field	19	8	11	
8	Self Inductance	20-22	9	12,13	3
9	Growth Of Current In LR Circuit	23-24		14-17	4
10	Energy Stored In Inductor	25,26	10	18	
11	Decay Of Current In LR Circuit	27		19	10,14,15
12	Mutual Inductance	28,29	11	20	6
13	Inductors In Series And Parallel	30		21	12
14	AC Generator	31,32		22	7,11,16
15	After Full Chapter		12		5

SINGLE CORRECT TYPE

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Magnetic Flux

Q1. A square of side *2* meters lies in the *x-y* plane in a region, where the magnetic field is given by $\vec{B} = B_0\left(2\hat{i} + 3\hat{j} + 4\hat{k}\right)T$, where B_o is constant. The magnitude of flux passing through the square is -

(A) $8B_o$ Wb. (B) $12B_o$ Wb.

(C) $16B_o$ Wb. (D) $\sqrt{4\times 29}B_0 Wb$

Faraday's Law of Induction

Q2. The dimension of the ratio of magnetic flux and the resistance is equal to that of :

(A) induced emf (B) charge

(C) inductance (D) current

Q3. In a circuit a coil of resistance 2Ω, then magnetic flux changes from 2.0Wb to 10.0Wb in 0.2 sec. The charge flow in the coil during this time is :-

(A) 5.0 C (B) 4.0 C

(C) 1.0 C (D) 0.8 C

Q4. According to Faraday's Laws of electro magnetic induction :–

(A) the direction of the induced current is such that it opposes the causes of change in flux.

(B) the induced emf in the coil is equal to the rate of change of magnetic flux associated with it

(C) the direction of induced emf is such that it opposes the causes of change in flux.

(D) none of the above

Q5. A coil of 100 turns having an average area of 100 cm^2 for each turn is held in a uniform field of 50 gauss, The direction of field being at right angles to the plane of coil. The field is removed in $\frac{1}{100}$ s. Average emf (in volts) induced in the coil is :-

(A) 0.5 V (B) 10 V

(C) 15 V (D) 50 V

Lenz's Law

Q6. The flux linked with a coil at any instant 't' is given by : $\phi = 10t^2 - 50t + 250$. The induced emf at t = 3s is-

(A) – 190 V (B) – 10 V

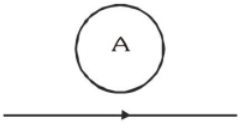
(C) 10 V (D) 190 V

Q7. A coil of resistance 1000Ω and 1000 turns have the magnetic flux line of 5.5×10^{-5} Wb. If the magnetic flux is changed to 5×10^{-5} Wb. in 0.1 sec. then the induced charge in coil is :–

(A) 50 μC (B) 5 μC

(C) 2 μC (D) 20 μC

Q8. As shown in the figure, a copper coil A and a wire are placed in the plane of the paper. A current of one ampere flows in the wire in the directions as shown in the figure. If the magnitude of the current is raised to 2 amp. What will be the direction of the induced current in the coil :-



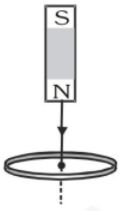
(A) anti clock wise

(B) clock wise

(C) no current will induced

(D) none of the above

Q9. Consider a metal ring kept on a horizontal plane. A bar magnet is held above the ring with its length along the axis of the ring. If the magnet is dropped freely the accelration of the falling magnet is (g is accelration due to gravity) :–



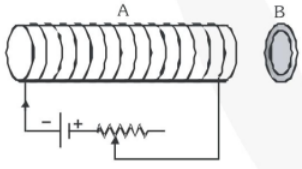
(A) more than g

(B) equal to g

(C) less than g

(D) depend on mass of magnet

Q10. An aluminium ring B faces an electromagnet A. The current I through A can be altered. Then which of the following statement is correct :–



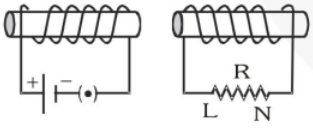
(A) if I decreases A will repel B

(B) whether I increases or decreases, B will not experience any force

(C) if I increases, A will repel B

(D) if I increases, A will attract B

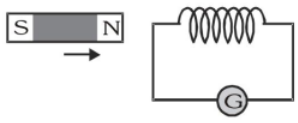
Q11. Two co–axial solenoids are shown in figure. If key of primary is suddenly opened then direction of instantaneous induced current in resistance 'R' in secondary is :-



(A) L to N (B) N to L

(C) alternating (D) zero

Q12. As shown in the figure, a magnet is brought towards a fixed coil quickly. Due to this the induced emf, current and the charge are E, I and Q respectively. If the speed of the magnet is doubled then which of the following statement is wrong :–



(A) E increases

(B) I increases

(C) Q does not change

(D) Q increases

Motional EMF

Q13. An aeroplane in which the distance between the tips of the wings is 50 meter is flying horizontally with a speed of 360 km/hour over a place where the vertical component of earth's magnetic field is 2.0×10^{-4} Testa. The potential difference between the tips of the wings would be :-

(A) 0.1 V (B) 1.0 V

(C) 0.2 V (D) 0.0

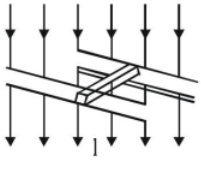
Q14. If the vertical component of earth's magnetic field be 6×10^{-5} Wb/m^2, then what will be the induced potential difference produced between the rails of a meter–gauge when a train is running on them with a speed of 36 km/h :–

(A) 2×10^{-4} V

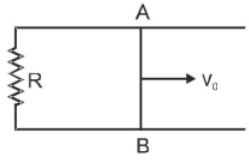
(B) 6×10^{-4} V

(C) 3×10^{-4} V

(D) 9×10^{-4} V



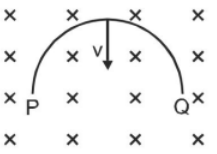
Q15. Two long parallel metallic wires with a resistance 'R' form a horizontal plane. A conducting rod AB is on the wires shown in figure. The space has magnetic field pointing vertically downwards. The rod is given an initial velocity 'v_0'. There is no friction in the wires and the rod. After a time 't' the velocity of the rod will be v such that :–



(A) $v > v_0$ (B) $v < v_0$

(C) $v = v_0$ (D) $v = -v_0$

Q16. A semicircle loop PQ of radius 'R' is moved with velocity 'v' in transverse magnetic field as shown in figure. The value of induced emf. at the end of loop is :-



(A) Bv (πr), end P at high potential

(B) 2BRv, end P at high potential

(C) 2BRv, end Q at high potential

(D) $B\frac{\pi R^2}{2}$ v, end P at high potential

Eddy Currents

Q17. Eddy current do not cause :-

(A) sparking

(B) loss of energy

(C) damping

(D) heating

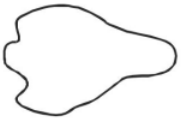
Q18. Plane of eddy circulations makes an angle with the external time varying field is :-

(A) 0° (B) 45°

(C) 180° (D) 90°

Induced Electric Field

Q19. As a result of change in the magnetic flux linked to the closed loop shown in the figure, an e.m.f. . V volt is induced in the loop. The work done (joules) in taking a charge Q coulomb once along the loop is :–



(A) QV (B) 0

(C) 2QV (D) $\frac{QV}{2}$

Self Inductance

Q20. When the current changes from 2A to 4A in 0.05 seconds in a coil, emf induced in the coil is 8V. The coefficient of self inductance in the coil will be :–

(A) 0.1 H (B) 0.2 H

(C) 0.4 H (D) 0.8 H

Q21 A coil of self inductance 2H carries a 2A current. If direction of current is reversed in 1 sec., then induced emf in it :-

(A) – 8V (B) 8V

(C) – 4V (D) Zero

Q22. Two coils are made of copper wires of same length In the first coil the number of turns is 3n and radius is r. In the second coil number of turns is n and radius is 3r the ratio of self inductances of the coils will be :-

(A) 9 : 1 (B) 1 : 1

(C) 1 : 3 (D) 1 : 9

Growth Of Current In LR Circuit

Q23. An LR circuit with a battery is connected at t = 0. Which of the following quantities is not zero just after the connection :-

(a) Current in circuit

(b) Magnetic potential energy in the inductor

(c) Power delivered by the battery

(d) Emf induced in the inductor

(A) a, b (B) a, c

(C) c, d (D) Only d

Q24. An L-R circuit consists of an inductance of 8 mH and a resistance of 4 Ω. The time constant of the circuit is :-

(A) 2 ms (B) 12 ms

(C) 32 ms (D) 500 s

Energy Stored In Inductor

Q25. A circular iron, core supports N turns. If a current I produces a magnetic flux ϕ across the core's cross section, then the magnetic energy is :-

(A) $I\phi$ (B) $\frac{1}{2} i\phi$

(C) $I\phi$ (D) $I^2\phi$

Q26. An inductor coil stores U energy when i current is passed through it and dissipates energy at the rate of P. The time constant of the circuit, when this coil is connected across a battery of zero internal resistance is -

(A) $\frac{4U}{P}$ (B) $\frac{U}{P}$

(C) $\frac{2U}{P}$ (D) $\frac{2P}{U}$

Decay Of Current In LR Circuit

Q27. **Statement–1** : At any instant, if the current through an inductor is zero, then the induced emf must be zero.

Statement–2 : An inductor tends to keep the flux constant.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is True; Statement–2 is NOT a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Mutual Inductance

Q28. Two coils are placed close to each other. The mutual inductance of the pair of coils depends upon-

(A) the rates at which currents are changing in the two coils

(B) relative position and orientation of the two coils

(C) the materials of the wires of the coils

(D) the currents in the two coils

Q29. The mutual inductance of the two coils is 1.25 henry. In the first coil, the current changes at 80 amp/s, the value of induced emf in volts in the secondary coil will be :-

(A) 12.5 (B) 64

(C) 0.016 (D) 100

Inductors In Series And Parallel

Q30. The equivalent inductance of two inductances is 2.4 henry when connected in parallel and 10 henry when connected in series. The difference between the two inductances is:-

(A) 2 henry (B) 3 henry

(C) 4 henry (D) 5 henry

AC Generator

Q31. In an AC generator, a coil with N turns, all of the same area A and total resistance R, rotates with frequency ω in a magnetic field B. The maximum value of emf generated in the coil is-

(A) NABRω (B) NAB

(C) NABR (D) NABω

Q32. The working of dynamo is based on principle of :-

(A) electromagnetic induction

(B) conversion of mechanical energy into electricity

(C) magnetic effects of current

(D) heating effects of current

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The e.m.f. induced in a coil of wire, which is rotating in a magnetic field, does not depend on

(A) the angular speed of rotation

(B) the area of the coil

(C) the number of turns on the coil

(D) the resistance of the coil

Q2. A conducting loop is placed in a uniform magnetic field with its plane perpendicular to the field. An emf is induced in the loop if :-

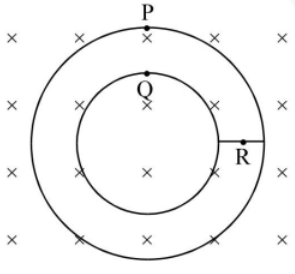
(A) It is translated within magnetic field

(B) It is rotated about its axis

(C) It is rotated about a diameter

(D) It is deformed

Q3. Figure shown plane figure made of a conductor located in a magnetic field along the inward normal to the plane of the figure. The magnetic field starts diminishing. Then the induced current



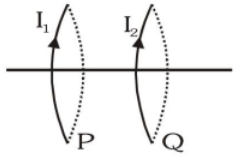
(A) at point P is clockwise

(B) at point Q is anticlockwise

(C) at point Q is clockwise

(D) at point R is zero

Q4. Two circular coils P & Q are fixed coaxially & carry currents I_1 and I_2 respectively.



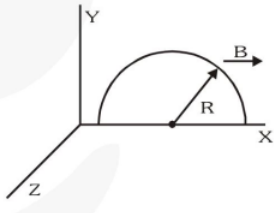
(A) If $I_2 = 0$ & P moves towards Q, a current in the same direction as I_1 is induced in Q.

(B) If $I_1 = 0$ & Q moves towards P, a current in the opp. direction to that of I_2 is induced in P

(C) when $I_1 \neq 0$ and $I_2 \neq 0$ are in the same direction then the two coils tend to move apart.

(D) when $I_1 \neq 0$ and $I_2 \neq 0$ are in opposite directions then the coils tends to move apart

Q5. A semicircle conducting ring of radius R is placed in the xy plane, as shown in the figure. A uniform magnetic field is set up along the x–axis. No emf, will be induced in the ring. If



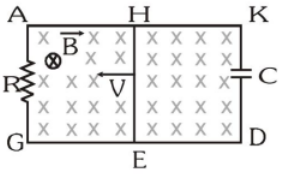
(A) it moves along the x–axis

(B) it moves along the y–axis

(C) it moves along the z–axis

(D) All of these

Q6. In the circuit shown in figure, a conducting wire HE is moved with a constant speed V towards left. The complete circuit is placed in a uniform magnetic field $\vec{B}$ perpendicular to the plane of the circuit directed in inward direction.



The current in HKDE is -

(A) clockwise

(B) anticlockwise

(C) alternating

(D) zero

Q7. When a metallic sphere is moved in a magnetic field, it gets heated due to :–

(A) direct current

(B) eddy currents

(C) alternating current

(D) additional current

Q8. A conducting ring of radius 1 meter is placed in an uniform magnetic field B of 0·01 Tesla oscillating with frequency 100 Hz with its plane at right angles to B. What will be the induced electric field:

(A) π volts/m (B) 2π volts/m

(C) 10 volts/m (D) 62 volts/m

Q9. Self induction of solenoid is :-

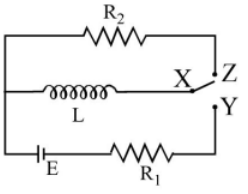
(A) directly proportional to current flowing through the coil

(B) directly proportional to its length

(C) directly proportional to area of cross–section

(D) inversely proportional to area of cross-section

Q10. In the circuit shown, X is joined to Y for a long time, and then X is joined to Z. The total heat produced in R_2 is :



(A) $\frac{LE^2}{2R_1^2}$ (B) $\frac{LE^2}{2R_2^2}$

(C) $\frac{LE^2}{2R_1R_2}$ (D) $\frac{LE^2R_2}{2R_1^2}$

Q11. Two coils have a mutual inductance 0.005H. The current changes in the first coil according to the equation $I = I_0 \sin\omega t$, where $I_0 = 10A$ and $\omega = 100\pi$ rad/s. The maximum value of emf in the second coil will be :–

(A) 5π (B) 10π (C) 2.5π (D) 15π

Q12. Magnetic field which keeps the particles in circular path of fixed radius keeping speed constant must :-

(A) Remain a constant every where

(B) Increase gradually

(C) Decrease gradually

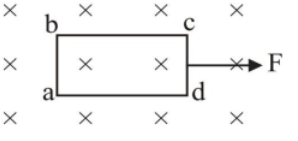
(D) None of these

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for question nos. 13 to 15

A rectangular frame of wire abcd has dimensions 32 cm × 8.0 cm and a total resistance of 2.0 Ω. It is pulled out of a magnetic field B = 0.020 T by applying a force of 3.2×10^{-5} N (figure). It is found that the frame moves with constant speed.



Q13. The constant speed of the frame is–

(A) 25 m/s (B) 20 m/s

(C) 16 m/s (D) 7.5 m/s

Q14. The emf induced in the loop is–

(A) 8.0×10^{-2} V (B) 5.0×10^{-2} V

(C) 2.0×10^{-2} V (D) 4.0×10^{-2} V

Q15. The potential difference between the points a and b is equal to -

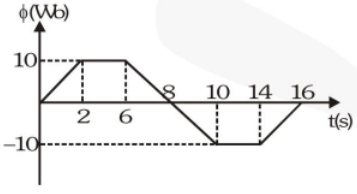
(A) 4.8×10^{-2} V (B) 3.6×10^{-2} V

(C) 2.4×10^{-2} V (D) 1.6×10^{-2} V

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q16. Magnetic flux in a circular coil of resistance 10Ω changes with time as shown in figure. ⊗ direction indicates a direction perpendicular to paper inwards. Match the following table :



Column–I	Column–II
(A) At 1s induced current is	(p) clockwise
(B) At 5s induced current is	(q) anticlockwise
(C) At 9s induced current is	(r) zero
(D) At 15 s induced current is	(s) 2A
	(t) None of these

NUMERICAL TYPE

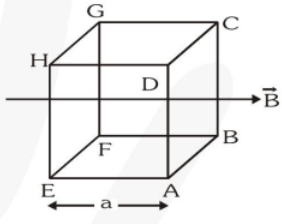
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q17. The magnetic field perpendicular to the plane of a loop of area 0.1 m^2 is 0.2 T. Calculate the magnetic flux through the loop (in wb).

SUBJECTIVE TYPE

Q18. A coil of 100 turns and area 5cm^2 is placed in a external magnetic field of 0.2 Tesla (S.I), in such a way that it makes an angle 30° with the field direction. Calculate magnetic flux through the coil (in weber).

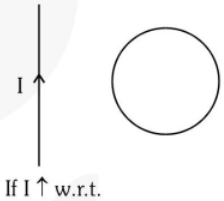
Q19. A square cube of side 'a' is placed in uniform magnetic field 'B'. Find magnetic flux through each face of the cube.



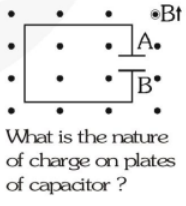
Q20. Find direction of induced current for the given cases :–

(Where w.r.t. = with respect to time, ob = observer =)

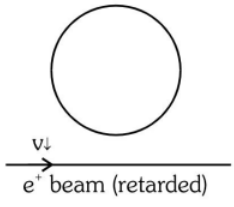
(i)



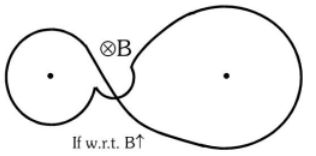
(ii)



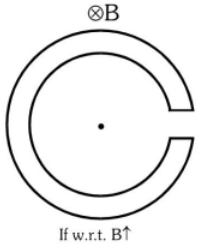
(iii)



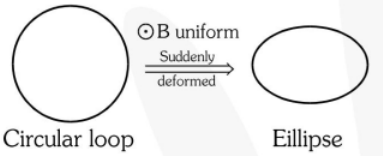
(iv) (a)



(b)

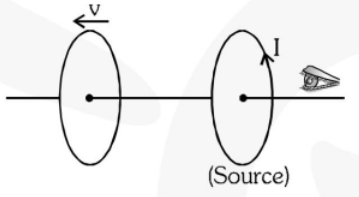


(v)

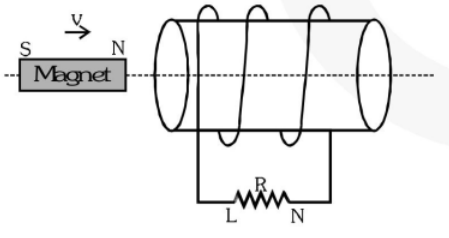


Q21. Find direction of induced current in the given cases :–

(i) (a)



(ii) What is the direction of induced current in resistance 'R' ?



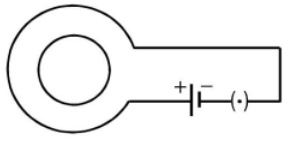
Q22. Find direction of instantaneous induced current in secondary circuit for the following changes in primary circuit :-

(a) Key is just closed

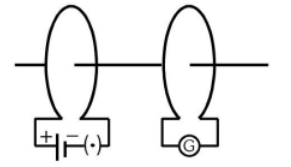
(b) Some time after the closing of key

(c) Key is just opened

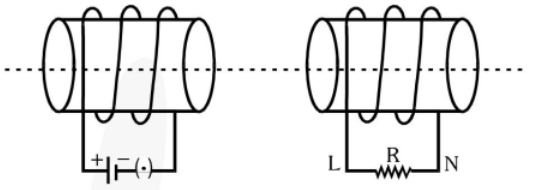
(i)



(ii)

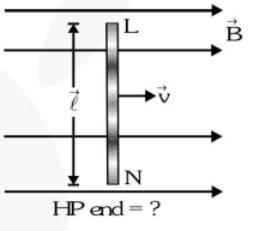


(iii)



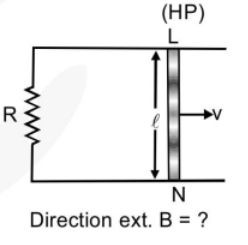
Q23. Find the Given Parameter when straight conductor moves in external magnetic field:-

(i)

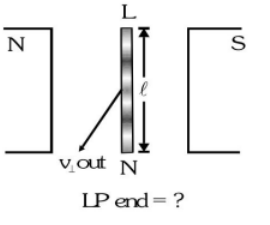


High Potential End

(ii)



(iii)



low Potential End

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. A ring of resistance 10Ω, radius 10cm and 100 turns is rotated at a rate 100 revolutions per second about its diameter is perpendicular to a uniform magnetic field of induction 10mT. The amplitude of the current in the loop will be nearly (Take : $\pi^2 = 10$)

(A) 200A (B) 2A

(C) 0.002A (D) none of these

Q2. A coil and a magnet moves with their constant speeds 5 m/sec. and 3 m/sec. respectively, towards each other, then induced emf in coil is 16 mV. If both are moves in same direction, then induced emf in coil:-

(A) 15 mV (B) 4 mV

(C) 64 mV (D) Zero

Q3. The radius of a circular coil having 50 turns is 2 cm. Its plane is normal to the magnetic field. The magnetic field changes from 2T to 4T in 3.14 sec. The induced emf in coil will be :–

(A) 0.4V (B) 0.04V

(C) 4 mV (D) 0.12 V

Q4. A short bar magnet allowed to fall along the axis of horizontal metallic ring. Starting from rest, the distance fallen by the magnet in one second may be :–

(A) 4.0 m. (B) 5.0 m.

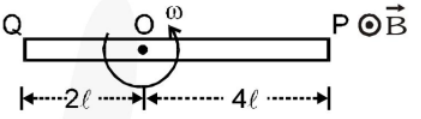
(C) 6.0 m. (D) 7.0 m.

Q5. Two parallel long straight conductors lie on a smooth surface. Two other parallel conductors rest on them at right angles so as to form a square of side a initially. A uniform magnetic field B exists at right angles to the plane containing the conductors. They all start moving out with a constant velocity v. If r is the resistance per unit length of the wire the current in the circuit will be

(A) $\frac{Bv}{r}$ (B) $\frac{Br}{v}$

(C) Bvr (D) Bv

Q6. A conducting rod rotates with a constant angular velocity 'ω' about the axis which passes through point 'O' and perpendicular to its length. A uniform magnetic field 'B' exists parallel to the axis of the rotation. Then potential difference between the two ends of the rod is :-



(A) $6B\omega\ell^2$ (B) $B\omega\ell^2$

(C) $10B\omega\ell^2$ (D) zero

Q7. A semicircular wire of radius R is rotated with constant angular velocity ω about an axis passing through one end and perpendicular to the plane of the wire. There is a uniform magnetic field of strength B. The induced e.m.f. between the ends is -

(A) $B\omega R^2/2$ (B) $2B\omega R^2$

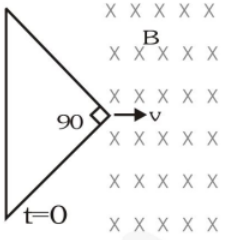
(C) is variable (D) none of these

Q8. The magnetic field in a region is given by $\vec{B} = B_0\left(1+\frac{x}{a}\right)\hat{k}$. A square loop of edge length d is placed with its edge along x & y axis. The loop is moved with constant velocity $\vec{v} = V_0\hat{i}$. The emf induced in the loop is

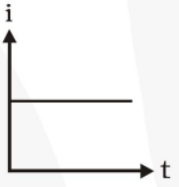
(A) $\frac{V_0B_0d^2}{a}$ (B) $\frac{V_0B_0d^2}{2a}$

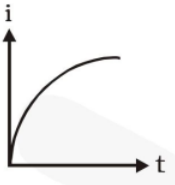
(C) $\frac{V_0B_0a^2}{d}$ (D) none

Q9. The figure shows an isosceles triangle wire frame with apex angle equal to $\pi/2$. The frame starts entering into the region of uniform magnetic field B with constant velocity v at t = 0. The longest side of the frame is perpendicular to the direction of velocity. If i is the instantaneous current through the frame then choose the alternative showing the correct variation of i with time.



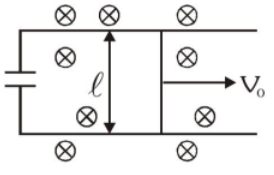
(A)

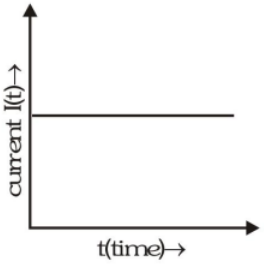
(B) 

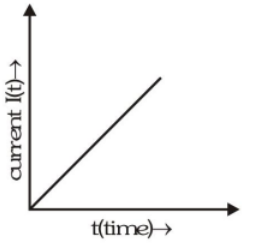
(C) 

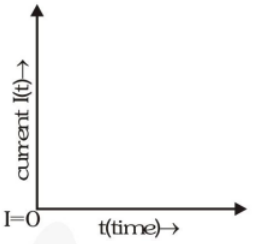
(D)

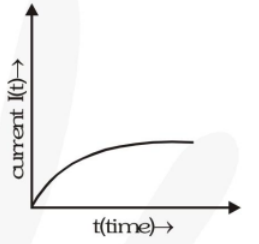
Q10. Two infinitely long conducting parallel rails are connected through a capacitor C as shown in the figure. A conductor of length ℓ is moved with constant speed v_0 in uniform magnetic field B. Which of the following graph truly depicts the variation of current through the conductor with time?



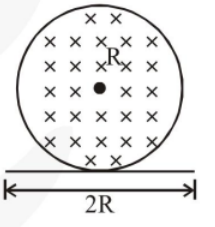
(A) 

(B) 

(C) 

(D) 

Q11. A uniform but time varying magnetic field is present in a circular region of radius R. The magnetic field is perpendicular and into the plane of the loop and the magnitude of field is increasing at a constant rate α. There is a straight conducting rod of length 2R placed as shown in figure. The magnitude of induced emf across the rod is



(A) $\pi R^2\alpha$ (B) $\frac{\pi R^2\alpha}{2}$

(C) $\frac{R^2\alpha}{\sqrt{2}}$ (D) $\frac{\pi R^2\alpha}{4}$

Q12. The self inductance of a toroid is :-

(A) $\frac{\mu_0 N^2 r^2}{2\,R_m}$ (B) $\frac{\mu_0 N^2 \pi r}{2R_m}$

(C) $\frac{\mu_0 N^2 r}{2R_m}$ (D) $\frac{\mu_0 N^2 r\pi}{R_m}$

Q13. A wire of fixed length is wound on a solenoid of length 'ℓ' and radius 'r'. Its self inductance is found to be L. Now if same wire is wound on a solenoid of length $\ell/2$ and radius r/2, then the self inductance will be -

(A) 2 L (B) L (C) 4 L (D) 8 L

Q14. An e.m.f. of 15 volt is applied in a circuit containing 5 henry inductance and 10 ohm resistance. The ratio of the currents at time $t \to \infty$ and at t = 1 second is:-

(A) $\frac{e^{1/2}}{e^{1/2}-1}$ (B) $\frac{e^2}{e^2-1}$

(C) $1-e^{-1}$ (D) $e^{-1}d$

Q15. A coil of $L=5\times10^{-3}$ H and R=18 Ω is abruptly supplied a potential of 5 volts. What will be the rate of change of current in 0.001 second ? ($e^{-3.6} = 0.0273$)

(A) 27.3 amp/sec. (B) 27.8 amp/sec.

(C) 2.73 amp/sec. (D) 2.78 amp/sec.

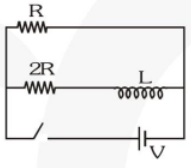
Q16. The ratio of time constant in charging and discharging in the circuit shown in figure is

(A) 1:1

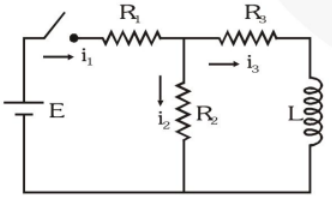
(B) 3:2

(C) 2:3

(D) 1:3



Q17. In the circuit shown in adjoining fig E = 10V, $R_1 = 1\Omega$ $R_2 = 2\Omega$, $R_3 = 3\Omega$ and L = 2H. Calculate the value of current i_1, i_2 and i_3 immidiately after key S is closed :-



(A) 3.3 amp, 3.3 amp, 3.3 amp

(B) 3.3 amp, 3.3 amp, 0 amp

(C) 3.3 amp, 0 amp, 0 amp

(D) 3.3 amp, 3.3 amp 1.1 amp

Q18. If a current of 2A give rise a magnetic flux of 5×10^{-5} weber/turn through a coil having 100 turns, then the magnetic energy stored in the medium surrounding by the coil is :-

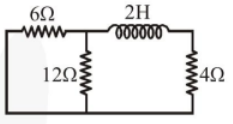
(A) 5 joule

(B) 5×10^{-7} joule

(C) 5×10^{-3} joule

(D) 0.5 joule

Q19. In the given circuit containing an inductor and resistors the time constant of the circuit is :-



(A) $\frac{1}{2}$s (B) $\frac{1}{8}$s

(C) $\frac{1}{6}$s (D) $\frac{1}{4}$s

Q20. Two coils of self inductances 2 mH and 8 mH are placed so close together that the effective flux in one coil is completely linked with the other. The mutual inductance between these coils is :-

(A) 10 mH (B) 6 mH

(C) 4 mH (D) 16 mH

Q21. An inductance coil have the time constant 4 sec. If it is cut into two equal parts and connected in parallel then new time constant of the circuit is :-

(A) 4 sec (B) 2 sec

(C) 1 sec (D) 0.5 sec

Q22. A circular coil of mean radius of 7 cm and having 4000 turns is rotated at the rate of 1800 revolutions per minute in the earth's magnetic field (B = 0.5 gauss), the peak value of emf induced in coil will be : (Take $\pi^2 = 10$)

(A) 1.158 V (B) 0.588 V

(C) 0.29 V (D) 5.8 V

ONE OR MORE THAN ONE CORRECT TYPE

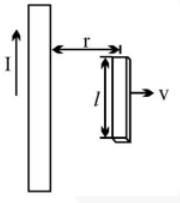
Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The radius of a coil decreases steadily at the rate of 10^{-2} m/s. A constant and uniform magnetic field of induction 10^{-3} Wb/m^2 acts perpendicular to the plane of the coil. The radius of the coil when the induced e.m.f. in the coil is 1μV, is :-

(A) $\frac{2}{\pi}$ cm (B) $\frac{3}{\pi}$ cm

(C) $\frac{4}{\pi}$ cm (D) $\frac{5}{\pi}$ cm

Q2. A conducting rod moves with constant velocity υ perpendicular to the long, straight wire carrying a current I as shown. Compute the emf generated between the ends of the rod.



(A) $\frac{\mu_0 v I l}{\pi r}$

(B) $\frac{\mu_0 v I l}{2\pi r}$

(C) $\frac{2\mu_0 v I l}{\pi r}$

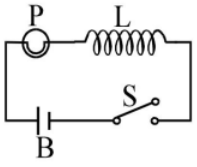
(D) $\frac{\mu_0 v I l}{4\pi r}$

Q3. A coil of 10^{-2} H inductance carries a current I = 2sin(100t)A. When current is half of its peak value then at that instant the induced emf in coil :-

(A) 1V (B) $\sqrt{2}$ V

(C) $\sqrt{3}$ V (D) 2V

Q4. In figure, a lamp P is in series with an iron-core inductor L. When the switch S is closed, the brightness of the lamp rises relatively slowly to its full brightness than it would do without the inductor. This is due to -



(A) the low resistance of P

(B) the induced-emf in L

(C) the low resistance of L

(D) the high voltage of the battery B

Q5. A long straight wire of circular cross-section is made of a non-magnetic material. The wire is of radius a. The wire carries a current I which is uniformly distributed over its cross-section. The energy stored per unit length in the magnetic field contained within the wire is.

(A) $U = \frac{\mu_0 I^2}{8\pi}$ (B) $U = \frac{\mu_0 I^2}{16\pi}$

(C) $U = \frac{\mu_0 I^2}{4\pi}$ (D) $U = \frac{\mu_0 I^2}{2\pi}$

Q6. Two coil A and B have coefficient of mutual inductance M=2H. The magnetic flux passing through coil A changes by 4 Weber in 10 seconds due to the change in current in B. Then -

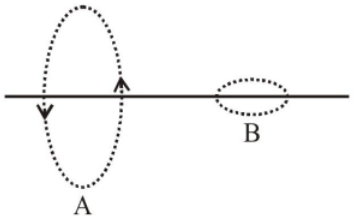
(A) Change in current in B in this time interval is 0.5 A.

(B) The change in current in B in this time interval is 2A.

(C) The change in current in B in this time interval is 8A.

(D) A change in current of 1A in coil A will produce a change in flux passing through B by 4 Weber.

Q7. In the given figure the centre of a small conducting circular loop B lies on the axis of bigger circular loop A and their axis are mutually perpendicular. An anticlockwise (when viewed from the side of B) current in the loop A start increasing then :-



(A) current induced in the loop B is in clockwise direction (when viewed from above the B)

(B) current induced in the loop B is in anti-clockwise direction (when viewed from above the B)

(C) current must induced in the loop B but its direction can not be predicted

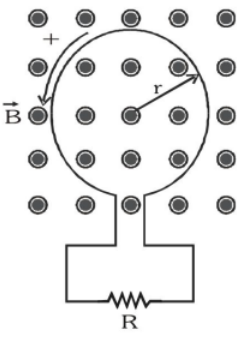
(D) no current is induced in the loop B

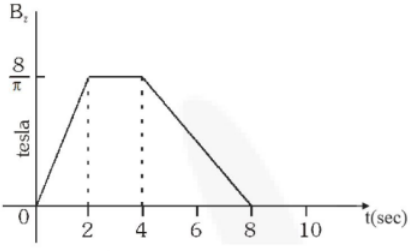
PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

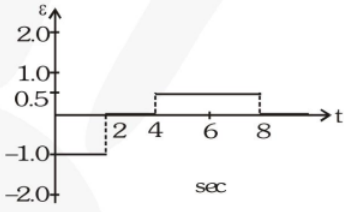
Paragraph for question nos. 8 to 9

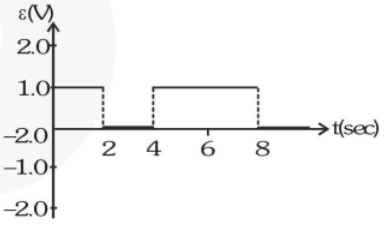
A uniform magnetic field $\vec{B}$ is perpendicular to a one-turn circular loop of wire of negligible resistance, as shown in the figure given below. The field changes with time as shown (the z direction is out of the page). The loop is of radius r = 50 cm and is connected in series with a resistor of resistance R = 20Ω. The "+" direction around the circuit is indicated in the figure.

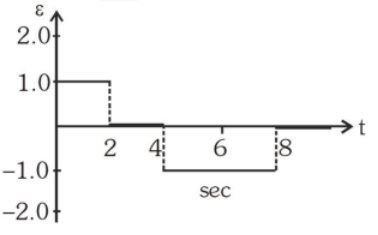


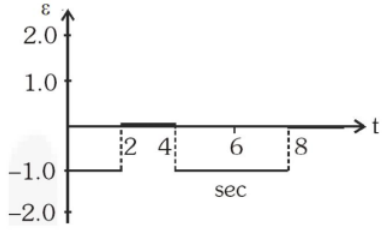


Q8. Graph of induced emf as a function of time is given by :-

(A)


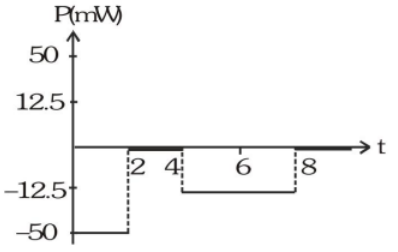
(B)


(C)


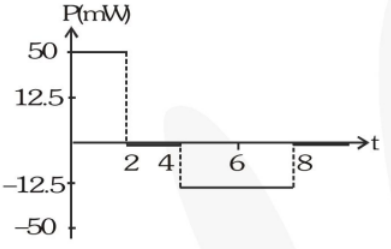
(D)


Q9. Plot the power dissipated in the resistor as a function of time.

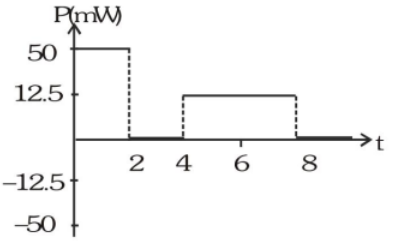
(A)



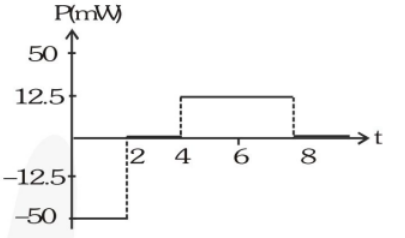
(B)



(C)



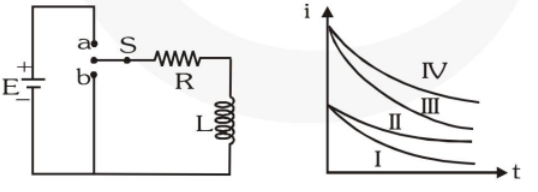
(D)



MATCH THE COLUMN TYPE

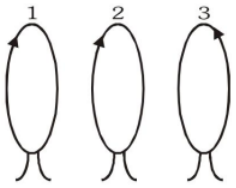
*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q10. The switch S in the circuit is connected with point 'a' for a very long time, then it is shifted to position 'b'. The resulting current through the inductor is shown by curves in the graph for four sets of values for the resistance R and inductance L (given in the left column). Which set corresponds with which curve?



Column I	**Column II**
(A) R_0 and L_0	(p) I
(B) $2R_0$ and L_0	(q) II
(C) R_0 and $2L_0$	(r) III
(D) $2R_0$ and $2L_0$	(s) IV

Q11. Three coils are placed infront of each other as shown. Currents in 1 and 2 are in same direction, while that in 3 is in opposite direction. Match the following table :



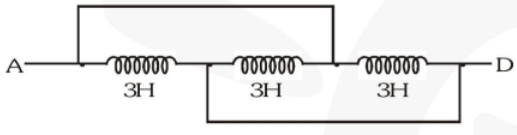
Column-I	Column-II
(a) When current in 1 is increased	(p) current in 1 will increase
(b) When current in 2 is increased	(q) current in 2 will increase
(c) When current in 3 is increased	(r) Current in 3 will increase
	(s) none of these

(A) (a - q), (b - p, r), (c -s)
(B) (a - r), (b - r), (c -p, q)
(C) (a - r), (b - q), (c -p)
(D) (a - s), (b - r), (c q)

NUMERICAL TYPE

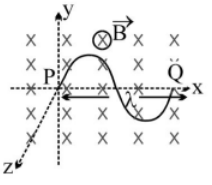
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q12. The inductance between A and D is-



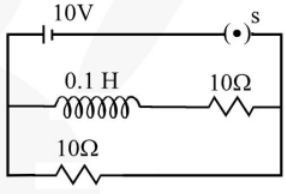
SUBJECTIVE TYPE

Q13. A wire forming one cycle of sine curve is moved in x-y plane with velocity $\vec{V} = V_x\hat{i} + V_y\hat{j}$. There exist a magnetic field $\vec{B} = -B_0\hat{k}$. Find the motional emf develop across the ends PQ of wire.



Q14. In a L–R decay circuit, the initial current at t = 0 is I. The total charge that has flown through the resistor till the energy in the inductor has reduced to one–fourth its initial value, is-

Q15. In the adjoining circuit, initially the switch S is open. The switch 'S' is closed at t = 0. The difference between the maximum and minimum current that can flow in the circuit is



Q16. An inductor of inductance 2.0mH,is connected across a charged capacitor of capacitance 5.0μF and the resulting LC circuit is set oscillating at its natural frequency. Let Q denote the instantaneous charge on the capacitor and I be the current in the circuit .It is found that the maximum value of Q is 200μC.

(a) when Q = 100μC, what is the value of $|dI/dt|$?

(b) when Q = 200 μC, what is the value of I ?

(c) Find the maximum value of I.

(d) when I is equal to one half its maximum value, what is the value of $|Q|$

Answer Key

Ex-1									
1	2	3	4	5	6	7	8	9	10
C	B	B	B, D	A	B	B	B	C	C
11	12	13	14	15	16	17	18	19	20
A	A	B	B	B	C	A	D	A	B
21	22	23	24	25	26	27	28	29	30
B	B	D	A	B	C	D	B	D	A
31	32								
D	A								

Ex-1A

1. D **2.** C,D **3.** A,C,D **4.** B, D **5.** D

6. D **7.** B **8.** A **9.** C **10.** A

11. A **12.** A **13.** A **14.** D **15.** B

16. (A) → (q) ; (B) → (r) ; (C) → (p) ; (D) → (q)

17. 0.02 Wb **18.** 5×10^{-3} weber. **19.** $\boxed{\phi_{net} = 0}$

20. (i) Anticlockwise
(ii) A – Positive charge, B – Negative charge
(iii) Anticlockwise
(iv) (a) Anti clockwise in bigger loop & clockwise in smaller loop
(b) Anti clockwise in bigger loop & clockwise in smaller loop
(v) Anticlockwise

21. (i) (a) Anticlockwise (ACW),
(b) Clockwise (CW)
(ii) N to L

22. (i) (a) ACW, (b) Zero, (c) CW
(ii) (a) ACW, (b) Zero, (c) CW
(iii) (a) L to N, (b) Zero, (c) N to L

23. (i) $e = 0$ as $\vec{v} \times \vec{B} = 0$
(ii) Magnetic field will be downward perpendicular to the plane paper ($\otimes$).
(iii) N will be at LP.

Ex-2									
1	2	3	4	5	6	7	8	9	10
B	B	B	A	A	A	B	A	D	C
11	12	13	14	15	16	17	18	19	20
D	A	A	B	A	B	B	C	D	C
21	22								
A	B								

Ex-2A

1. D **2.** B **3.** C **4.** B **5.** B

6. B **7.** D **8.** A **9.** C

10. (A) → (r); (B) → (p); (C) → (s); (D) → (q) **11.** B **12.** 1H

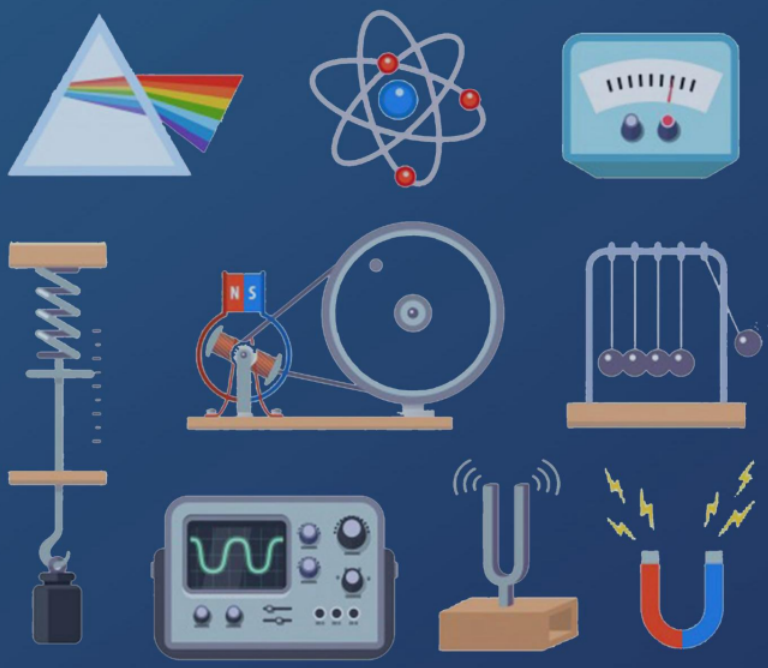
13. $\lambda V_y B_0$ **14.** $LI/2R$ **15.** 1A

16. (a) 10^4A/s (b) 0 (c) 2A (d) $100\sqrt{3}\,\mu$C

-: Important Notes & Formulas :-

PHYSICS

Electromagnetic Waves



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Note

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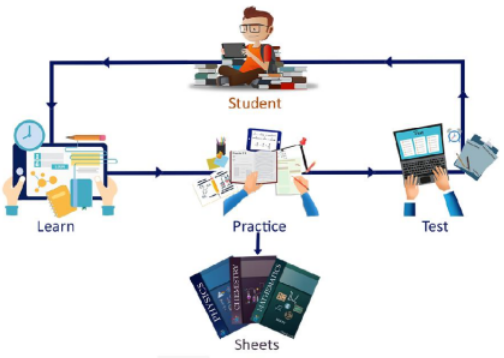
Module Description



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Do questions from 2 & 2A after attempting 1 & 1A

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3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

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Home Work Index

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Sr.No.	Topic Name	Ex-1	Ex-2
1	Displacement current	1-3	1-3
2	Electromagnetic wave	4-11	4-10
3	Energy in EM waves	12,13	11-13
4	Electromagnetic Spectrum	14,15	

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Displacement current

Q1. A large parallel plate capacitor, whose plates have an area of 1 m^2 and are separated from each other by 1 mm, is being charged at a rate of 25.8 V/s. If the dielectric between the plates has the dielectric constant 10, then the displacement current at this instant is :-

(A) 251 μA (B) 11 μA
(C) 2.2 μA (D) 1.1 μA

Q2. The conduction current is the same as displacement current when source is :-

(A) ac only (B) dc only
(C) both ac and dc (D) neither dc nor ac

Directions for Assertion & Reason Questions

These questions Consist of two Statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

(A) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.
(B) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.
(C) If Assertion is True but the Reason is false.
(D) If both Assertion & Reason are false.

Q3. The S.I unit of displacement current is-

(A) Henry (B) Coulomb
(C) Ampere (D) Farad

Electromagnetic wave

Directions for Assertion & Reason Questions

These questions Consist of two Statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

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(C) If Assertion is True but the Reason is false.
(D) If both Assertion & Reason are false.

Q4. **Assertion :-** Electromagnetic radiations exert pressure.

Reason :- EM-waves carry both momentum & energy.

(A) A (B) B
(C) C (D) D

Q5. The electric field associated with an e.m. wave in vacuum is given by

$\vec{E} = 40 \cos (kz - 6 \times 10^8 t)\hat{i}$,

where E, z and t are in volt/m, meter and seconds respectively. The value of wave vector k is:

(A) 6 m^{-1} (B) 3 m^{-1}
(C) 2 m^{-1} (D) 0.5 m^{-1}

Q6. A plane electromagnetic wave of frequency 40 MHz travels in free space in the X-direction. At some point and at some instant, the electric field $\vec{E}$ has its maximum value of 750 N/C in Y-direction. The wavelength of the wave is –

(A) 3.5 m (B) 5.5 m
(C) 7.5 m (D) 9.5 m

Q7. The speed of electromagnetic radiation in vacuum is :-

(A) $\mu_0 \epsilon_0$ (B) $\sqrt{\mu_0 \epsilon_0}$

(C) $\frac{1}{\mu_0 \epsilon_0}$ (D) $\frac{1}{\sqrt{\mu_0 \epsilon_0}}$

Q8. The nature of electromagnetic wave is –

(A) Longitudinal

(B) Longitudinal stationary

(C) Transverse

(D) Transverse stationary

Q9. A plane electromagnetic wave, $E_z = 100 \cos (6 \times 10^8 t + 4x)$ V/m propagates in a medium of dielectric constant :

(A) 1.5 (B) 2.0 (C) 2.4 (D) 4.0

Q10. A beam of light travelling along x-axis is described by the electric field,

$E_y = (600\ Vm^{-1}) \sin \omega (t - x/c)$

then maximum magnetic force on a charge $q = 2e$, moving along y-axis with a speed of $3.0 \times 10^7\ ms^{-1}$ is ($e = 1.6 \times 10^{-19}$ C) :

(A) 19.2×10^{-17} N (B) 1.92×10^{-17} N

(C) 0.192 N (D) None ofthese

Q11. A plane electromagnetic wave travelling along the X-direction has a wavelength of 3mm. The variation in the electric field occurs in the Y-direction with an amplitude $66 Vm^{-1}$.The equation for the electric and magnetic fields as a function of x and t are respectively.

(A) $E_y = 33 \cos \pi \times 10^{11} \left(t - \frac{x}{c}\right)$;

$B_z = 1.1 \times 10^{-7} \cos \pi \times 10^{11} \left(t - \frac{x}{c}\right)$

(B) $E_y = 11 \cos 2\pi \times 10^{11} \left(t - \frac{x}{c}\right)$;

$B_y = 1.1 \times 10^{-7} \cos 2\pi \times 10^{11} \left(t - \frac{x}{c}\right)$

(C) $E_x = 33 \cos \pi \times 10^{11} \left(t - \frac{x}{c}\right)$;

$B_x = 1.1 \times 10^{-7} \cos \pi \times 10^{11} \left(t - \frac{x}{c}\right)$

(D) $E_y = 66 \cos 2\pi \times 10^{11} \left(t - \frac{x}{c}\right)$;

$B_z = 2.2 \times 10^{-7} \cos 2\pi \times 10^{11} \left(t - \frac{x}{c}\right)$

Energy in EM waves

Q12. In an electromagnetic wave the average energy density is associated with –

(A) Electric field only

(B) Magnetic field only

(C) Equally with electric and magnetic fields

(D) Average energy density is zero

Q13. In the above problem, the average energy density associated with the electric field will be –

(A) $\frac{1}{2} CV^2$ (B) $\frac{1}{2} \frac{q^2}{C}$

(C) $\frac{1}{2} \frac{\varepsilon^2}{E}$ (D) $\frac{1}{2} \varepsilon_0 E^2$

Electromagnetic Spectrum

Q14. The frequency from 3×10^9 Hz to 3×10^{10} Hz is –

(A) High frequency band

(B) Super high frequency band

(C) Ultra high frequency band

(D) Very high frequency band

Q15. The frequency from 3 to 30 MHz is known as –

(A) Audio band

(B) Medium frequency band

(C) Very high frequency band

(D) High frequency band

Exercise - 2 — Brain Booster

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Instantaneous displacement current of 1.0A in the space between the parallel plates of 1μF capacitor can be established by changing potential difference of :

(A) 10^{-6} V/s (B) 10^{6} V/s

(C) 10^{-8} V/s (D) 10^{8} V/s

Q2. The maxwell's equation :

$\oint \vec{B}.\vec{dl} = \mu_0\left(i+\varepsilon_0.\frac{d\phi_E}{dt}\right)$ is a statement of-

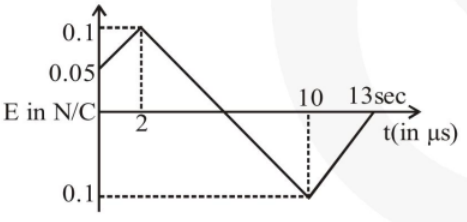
(A) Faraday's law of induction

(B) Modified Ampere's law

(C) Gauss's law of electricity

(D) Gauss's law of magnetism

Q3. The electric field through an area of $2m^2$ varies with time as shown in the graph. The greatest displacement current through the area is at :-



(A) t = 1 sec. (B) t = 4 sec.

(C) t = 8 sec. (D) t = 12 sec.

Q4. If $\vec{E}$ and $\vec{B}$ are the electric and magnetic field vectors of electromagnetic waves then the direction of propagation of electro-magnetic wave is along the direction of –

(A) $\vec{E}$ (B) $\vec{B}$

(C) $\vec{E} \times \vec{B}$ (D) none of these

Q5. Select wrong statement from the following for EMW -

(A) are transverse

(B) travel with same speed in all medium

(C) travel with the speed of light

(D) are produced by accelerating charge

Q6. The wave function (in S.I.units) for an electromagnetic wave is given as –

$\psi(x,t) = 10^3 \sin\pi(3\times10^6 x - 9\times10^{14} t)$

The speed of the wave is –

(A) 9×10^{14} m/s (B) 3×10^{8} m/s

(C) 3×10^{6} m/s (D) 3×10^{7} m/s

Q7. The electric field part of an electromagnetic wave in a medium is represented by $E_x = 0$;

$E_y = 2.5\ \frac{N}{C}\cos\left[\left(2\pi\times10^6\ \frac{rad}{m}\right)t - \left(\pi\times10^{-2}\ \frac{rad}{s}\right)x\right]$;

$E_z = 0$. The wave is :

(A) Moving along – x direction with frequency 10^6 Hz and wave length 200 m.

(B) Moving along + y direction with frequency $2\pi \times 10^6$ Hz and wave length 200 m.

(C) Moving along + x direction with frequency 10^6 Hz and wave length 100 m.

(D) Moving along + x direction with frequency 10^6 Hz and wave length 200 m.

Q8. An electromagnetic wave with frequency ω and wavelength λ travels in the + y direction. Its magnetic field is along-x axis. The vector equation for the associated electric field (of amplitude E_0) is :-

(A) $\vec{E} = E_0\cos\left(\omega t - \frac{2\pi}{\lambda}y\right)\hat{x}$

(B) $\vec{E} = -E_0\cos\left(\omega t + \frac{2\pi}{\lambda}y\right)\hat{x}$

(C) $\vec{E} = -E_0\cos\left(\omega t + \frac{2\pi}{\lambda}y\right)\hat{z}$

(D) $\vec{E} = E_0\cos\left(\omega t - \frac{2\pi}{\lambda}y\right)\hat{z}$

Q9. Which of these statements correctly describes the orientation of the electric field $(\vec{E})$, the magnetic field $(\vec{B})$ and velocity of propagation $(\vec{v})$ of an electromagnetic wave?

(A) $\vec{E}$ is perpendicular to $\vec{B}$; $\vec{v}$ may have any orientation relative to $\vec{E}$.

(B) $\vec{E}$ is perpendicular to $\vec{B}$; $\vec{v}$ may have any orientation perpcndicular to $\vec{E}$.

(C) $\vec{E}$ is parallel to $\vec{B}$; $\vec{v}$ is perpendicular to both $\vec{E}$ and $\vec{E}$.

(D) Each of the three vectors is perpendicular to the other two.

Q10. The rms value of the electric field of the light coming from the sun is 720 N/c. The average total energy density of the electromagnetic wave is :

(A) 4.58×10^{-6} J/m^3

(B) 6.37×10^{-9} J/m^3

(C) 81.35×10^{-12} J/m^3

(D) 3.3×10^{-3} J/m^3

Q11. During the propagation of electromagnetic waves in a medium :

(A) Electric energy density is equal to the magnetic energy density

(B) Both electric magnetic energy densities are zero

(C) Electric energy density is double of the magnetic energy density

(D) Electric energy density is half of the magnetic energy density.

Q12. The AM range of radiowaves have frequency –

(A) less than 30 MHz

(B) more than 30 MHz

(C) less than 20000Hz

(D) more than 20000Hz

Q13. The condition under which a microwave oven heats up a food item containing water molecules most efficiently is :-

(A) Infra-red waves produce heating in a microwave oven.

(B) The frequency of the microwaves must match the resonant frequency of the water molecules.

(C) The frequency of the microwaves has no relation with natural frequency of water molecules.

(D) Microwaves are heat waves, so always produce heating.

Answer Key

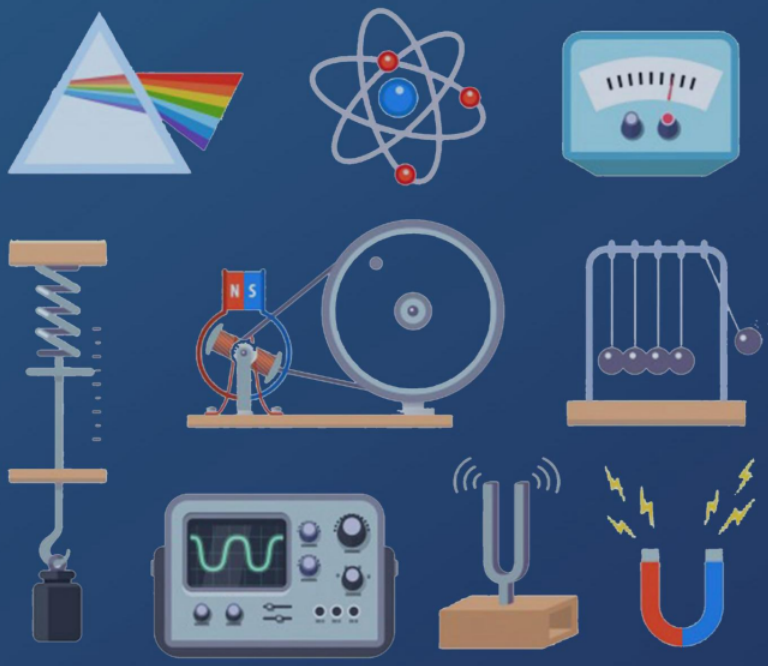
Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	C	C	A	C	C	D	C	D	B
11	**12**	**13**	**14**	**15**					
D	C	D	B	D					

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	B	D	C	B	B	D	D	D	A
11	**12**	**13**							
A	A	B							

-: Important Notes & Formulas :-

PHYSICS

Electrostatics



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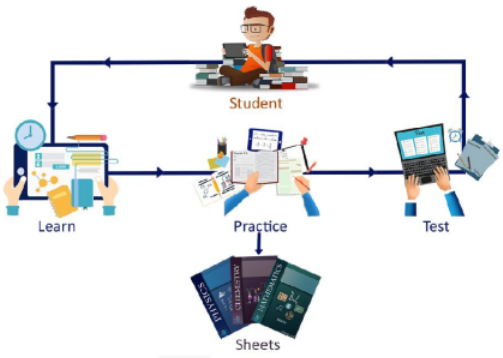

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Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Electric Charge	1			
2	Coulomb's Law	2-4		1,2	16-18
3	Charging by Friction & Induction		23		
4	Electric Field	5,6	1,2	3	
5	EFI on Axis of Uniformly Charged Ring			4	1
6	EFI Due to Thin Wire	7			
7	EFI due to Thin Circular Arc			5	
8	Electric Field Lines	8-10			
9	Electric Flux	11,12	22		19,20
10	Gauss Law	13	3-5	6,7	2
11	Gauss Law Application - EFI due to Sphere and Thin Shell	14			
12	Gauss Law Application - EFI due to Sphere	15,16		8,9	3
13	Gauss Law Application - EFI due to Solid and Hollow Cylinder , Infinite Sheet	17	6,24		4
14	Electrostatic Potential Energy	18			
15	Applying Work Energy Theorem	19,20	7	10,11,12	5,6,21-23
16	Electric Potential	21			
17	Calculation of Electric Potential	22	8,9,19,20		
18	Calculating Potential from Field	23-25	10,11,12,13		7
19	Calculating Field from Potential	26	25		8
20	Potential due to Sphere and Thin Shell	27		13,14	9
21	Equipotential Surface	28	14		
22	Electric Dipole and Dipole Moment	29			
23	Electris Field and Potential due to Dipole	30		15-17	
24	Dipole in External Electric Field	31	15,21		10
25	Equivalent Dipole Moment		16		
26	Conductors and its Properties	32			
27	EFI on Surface of Conductors	33			
28	Electric Potential due to Conductors	34,35		18-20	
29	Conductors with Cavity	36-38			24
30	Parallel Conducting Plates		17		
31	Electrostatic Pressure, Energy Density and Effect of Medium				
32	After full Chapter	39	18		11-15,25

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

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Electric Charge

Q1. Five balls numbered 1 to 5 are suspended using separate threads. Pairs (1,2); (2,4) and (4,1) show electrostatic attraction, while pairs (2,3) and (4,5) show repulson. The ball 1 may be :

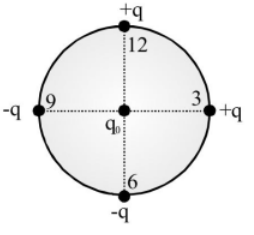
(A) positively charged
(B) negatively charged
(C) either (+ve) or (–ve)
(D) neutral

Coulomb's Law

Q2. Two equal and like charges when placed 5 cm apart experience a repulsive force of 0.144 newton. The magnitude of the charge in micro–coulomb will be

(A) 0.2 (B) 2
(C) 20 (D) 12

Q3. Four charges are placed at the circumference of dial clock as shown in figure. If the clock has only hour hand, then the resultant force on a charge q_0 placed at the centre, points in the direction which show the time as :-



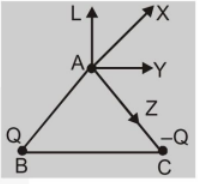
(A) 1:30 (B) 7:30
(C) 4:30 (D) 10:30

Q4. The dimensions of $\in_r$ is :–

(A) $[M^{-1} L^{-3} T^4 A^2]$ (B) $[M^0 L^{-3} T^2 A^3]$
(C) $[M^{-1} L^{-3} T^3 A]$ (D) Dimensionless

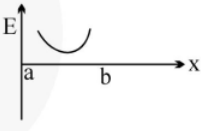
Electric Field

Q5. For the given figure the direction of electric field at A will be :



(A) towards AL (B) towards AY
(C) towards AX (D) towards AZ

Q6. Two point like charges a & b whose magnitudes are same are positioned at a certain distance from each other, a is at origin. Graph is drawn between electric field strength and distance x from a. E is taken positive if it is along the line joining from a to b



(A) a is positive, b is negative
(B) a & b both are positive
(C) a & b both are negative
(D) a is negative, b is positive

EFI Due to Thin Wire

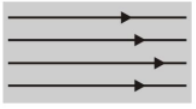
Q7. Two infinitely long parallel wires having linear charge densities λ_1 and λ_2 respectively are placed at a distance of R. The force per unit length of an either wire will be :–

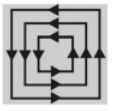
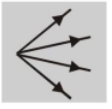
(A) $\frac{2k\lambda_1\lambda_2}{R^2}$ (B) $\frac{2k\lambda_1\lambda_2}{R}$

(C) $\frac{k\lambda_1\lambda_2}{R^2}$ (D) $\frac{\lambda_1\lambda_2}{R}$

Electric Field Lines

Q8. Which one of the following pattern of electrostatic line of force can't possible :–

(A)  (B)

(C)  (D) 

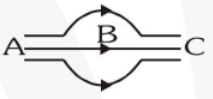
Q9. The figure shows some of the electric field lines corresponding to an eletric field. The figure suggests

(A) $E_A > E_B > E_C$

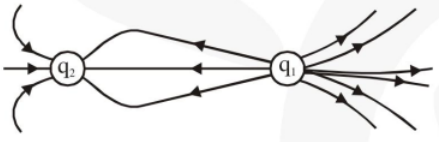
(B) $E_A = E_B = E_C$

(C) $E_A = E_C > E_B$

(D) $E_A = E_C < E_B$



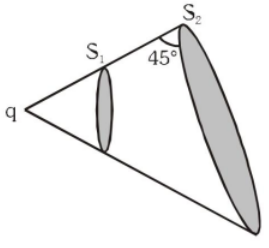
Q10. For the figure shown, what is the ratio of the charges q_2/q_1, where the figure shown has a representation of the field lines in the space near the charges.



(A) –3/2 (B) –2/3 (C) 2/3 (D) 3/2

Electric Flux

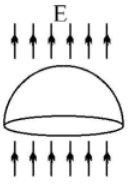
Q11. In the given figure flux through surface S_1 is ϕ_1 & through S_2 is ϕ_2. Which is correct?



(A) $\phi_1 = \phi_2$ (B) $\phi_1 > \phi_2$

(C) $\phi_1 < \phi_2$ (D) None of these

Q12. A hemispherical surface (half of a spherical surface) of radius R is located in a uniform electric field E that is parallel to the axis of the hemisphere. What is the magnitude of the electric flux through the hemisphere surface?

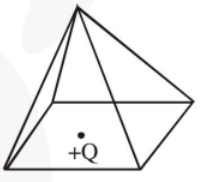


(A) 0 (B) $4\pi R^2E/3$

(C) $2\pi R^2E$ (D) πR^2E

Gauss Law

Q13. A point charge +Q is positioned at the center of the base of a square pyramid as shown. The flux through one of the four identical upper faces of the pyramid is



(A) $\frac{Q}{16\varepsilon_0}$ (B) $\frac{Q}{4\varepsilon_0}$

(C) $\frac{Q}{8\varepsilon_0}$ (D) None of these

Gauss Law Application - EFI due to Sphere and Thin Shell

Q14. Electric field inside a hollow uniformly charged sphere is :–

(A) Zero

(B) proportional to a distance from centre

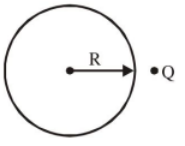
(C) inversly proportional to the distance

(D) inversly proportional to square of distance

Gauss Law Application - EFI due to Sphere

Q15. **Statement 1:** A charge is outside the Gaussian sphere of radius R. Then electric field on the surface of sphere is zero.

Statement 2 : As $\oint \vec{E} \cdot d\vec{s} = \frac{q_{in}}{\varepsilon_0}$, for the sphere q_{in} is zero, so $\oint \vec{E} \cdot d\vec{s} = 0$.



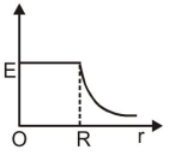
(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

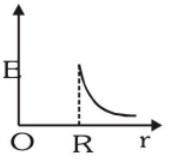
(C) Statement-1 is true, statement-2 is false.

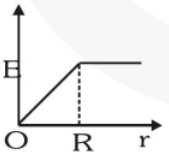
(D) Statement-1 is false, statement-2 is true.

Q16. The electric field due to a uniformly charged non conducting sphere of radius R as a function of the distance from its centre is represented graphically by

(A) 

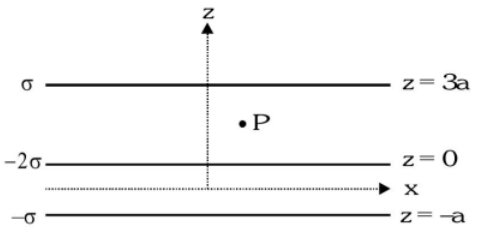
(B)

(C) 

(D) 

Gauss Law Application - EFI due to Solid and Hollow Cylinder, Infinite Sheet

Q17. Three infinitely long charge sheets are placed which charge density as shown in figure. The electric field at point P is :–

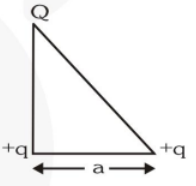


(A) $\frac{2\sigma}{\varepsilon_0}\hat{k}$ (B) $-\frac{2\sigma}{\varepsilon_0}\hat{k}$

(C) $\frac{4\sigma}{\varepsilon_0}\hat{k}$ (D) $-\frac{4\sigma}{\varepsilon_0}\hat{k}$

Electrostatic Potential Energy

Q18. Three charges Q, +q and +q are placed at the vertices of a right angle triangle (isoscles triangle) as shown. The net electrostatic energy of the configuration is zero, if Q is equal to :

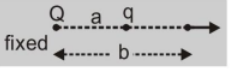


(A) $\frac{-q}{1+\sqrt{2}}$ (B) $\frac{-2q}{2+\sqrt{2}}$

(C) –2q (D) +q

Applying Work Energy Theorem

Q19. A charge $q = 10^{-6}$ C of mass 2 g (fig.) is free to move then calculate its speed, when it is at a distance of b.[Assume a = 1 m,b = 10 m, $Q = 10^{-3}$ C]



(A) 90 m/s. (B) 9 m/s.

(C) 900 m/s. (D) none of these

Q20. A particle of mass m and charge q is released from rest in an electric field E. Then the K. E after time t will be:

(A) $\frac{2E^2t^2}{mq}$ (B) $\frac{E^2q^2t^2}{2m}$

(C) $\frac{Eq^2m}{2t^2}$ (D) $\frac{Eqm}{2t}$

Electric Potential

Q21. At any point on the perpendicular bisector of line joining two equal and opposite charges

(A) The electric field is zero

(B) The electric potential is zero

(C) The electric potential decreases with increasing distance from centre

(D) The electric field is perpendicular to the line joining the charges

Calculation of Electric Potential

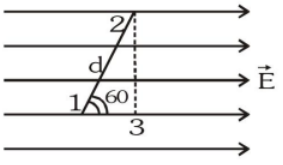
Q22. The electric potential and electric field at any given position due to a point charge are 600 V and 200 N/C respectively. Then magnitude of point charge would be :

(A) 3 μC (B) 30 μC

(C) 0.2 μC (D) 0.5 μC

Calculating Potential from Field

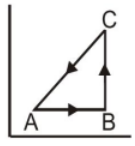
Q23. The electric field $\vec{E}$ between two points is constant in both magnitude and direction. Consider a path of lenght d at an angle $\theta = 60^0$ with respect to field lines shown in figure. The potential difference between points 1 and 2 is :



(A) $\frac{E}{d\cos 60°}$ (B) $Ed\cos 60°$

(C) $\frac{Ed}{\cos 60°}$ (D) $\frac{E}{d}\cos 60°$

Q24. As shown in figure, on bringing a charge Q from point A to B and from B to C, the work done are 2 joule and – 3 joule respectively. The work done in bringing the charge from C to A will be



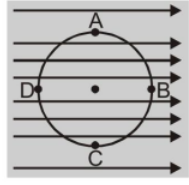
(A) – 1 joule

(B) 1 joule

(C) 2 joule

(D) 5 joule

Q25. A circle of radius R is drawn in a uniform electric field E as shown in the fig. V_A, V_B, V_C and V_D are respectively the potential of point A, B, C and D at the periphery of the circle then -



(A) $V_A > V_C$, $V_B = V_D$

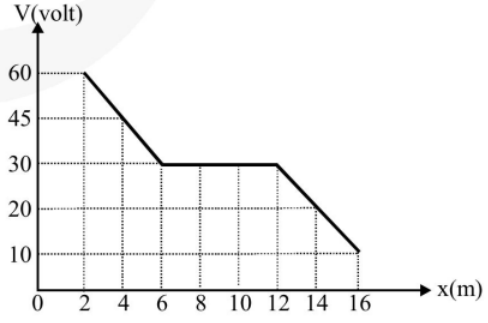
(B) $V_A < V_C$, $V_B = V_D$

(C) $V_A = V_C$, $V_B < V_D$

(D) $V_A = V_C$, $V_B > V_D$

Calculating Field from Potential

Q26. The variation of potential with distance x from a fixed point is shown in figure. The electric field at x =13m is -

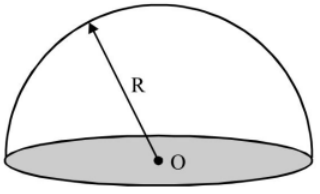


(A) 7.5 volt/meter (B) –7.5 volt/meter

(C) 5 volt/meter (D) –5 volt/meter

Potential due to Sphere and Thin Shell

Q27. Charge Q coulombs is uniformly distributed throughout the volume of a solid hemisphere of radius R metres. Then the potential at centre O of the hemisphere in volts is -

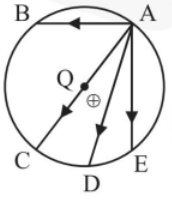


(A) $\frac{1}{4\pi\varepsilon_0}\frac{3Q}{2R}$ (B) $\frac{1}{4\pi\varepsilon_0}\frac{3Q}{4R}$

(C) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{4R}$ (D) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{8R}$

Equipotential Surface

Q28. In the electric field of charge Q, another charge is carried from A to B, A to C, A to D and A to E, then work done will be :-



(A) minimum along path AB
(B) minimum along path AD
(C) minimum along path AE
(D) zero along all the paths

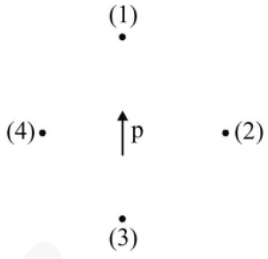
Electric Dipole and Dipole Moment

Q29. Two charges +2C and -2C are kept 3 mm apart. What is the magnitude of dipole moment of this setup.

(A) 0 (B) 6 Cm
(C) 0.006 Cm (D) 2 Cm

Electric Field and Potential due to Dipole

Q30. The drawing shows four points surrounding an electric dipole. Which one of the following expressions best ranks the electric potential at these four locations?



(A) $1 > 2 = 4 > 3$
(B) $3 > 2 > 4 > 1$
(C) $3 > 2 = 4 > 1$
(D) $2 = 4 > 1 = 3$

Dipole in External Electric Field

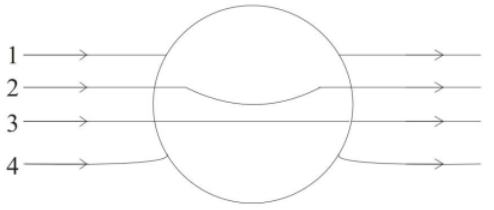
Q31. A point particle of mass M is attached to one end of a massless rigid non-conducting rod of length L. Another point particle of same mass is attached to the other end of the rod. The two particles carry charges +q and – q repectively. This arrangement is held in a region of uniform electric field E such that the rod makes a small angle θ ($< 5^0$) with the field direction. The minimum time needed for the rod to become parallel to the field after it is set free. (rod rotates about centre of mass)

(A) $2\pi\sqrt{\frac{ML}{2qE}}$ (B) $\pi\sqrt{\frac{ML}{2qE}}$

(C) $\frac{\pi}{2}\sqrt{\frac{ML}{2qE}}$ (D) $4\pi\sqrt{\frac{ML}{2qE}}$

Conductors and its Properties

Q32. A metallic solid sphere is placed in a uniform electric field. The lines of force follow the path (s) shown in figure as :

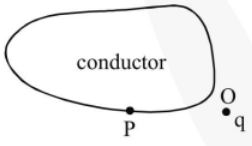


(A) 1 (B) 2 (C) 3 (D) 4

EFI on Surface of Conductors

Q33. The density of charge at P on the conductor is σ. The resultant electric field near P will [$\hat{n}$ = unit normal vector at point P.

$\vec{r}$ = vector along OP] where K = 1/4 $\pi\varepsilon_0$



(A) $\left(\frac{\sigma}{\epsilon_0}\right)\hat{n}+\left(\frac{Kq\vec{r}}{r^3}\right)$

(B) $\left(\frac{\sigma}{2\epsilon_0}\right)\hat{n}+\left(\frac{Kq\vec{r}}{r^3}\right)$

(C) $\left(\frac{\sigma}{\epsilon_0}\right)\hat{n}$

(D) $\left(\frac{\sigma}{2\epsilon_0}\right)\hat{n}$

Electric Potential due to Conductors

Q34. **Statement–1 :** If a point charge q is placed in front of an infinite grounded conducting plane surface, the point charge will experience a force.

Statement–2 : This force is due to the induced charge on the conducting surface which is at zero potential.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is True; Statement–2 is not a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Q35. **Statement–1 :** If two concentric conducting sphere which are connected by a conducting wire. No charge can exist on inner sphere.

Statement–2 : When charge on outer sphere will exist then potential of inner shell and outer shell will be same.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is False.

(C) Statement–1 is False, Statement–2 is True.

(D) Statement–1 is True, Statement–2 is True; Statement–2 is not a correct explanation for Statement–1.

Conductors with Cavity

Q36. **Statement–1 :** Induced charge does not contribute to electric field or potential at a given point.

Statement–2 : A point charge q_0 is kept outside a solid metallic sphere, the electric field inside the sphere is zero.

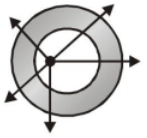
(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

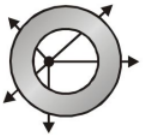
(B) Statement–1 is True, Statement–2 is True; Statement–2 is not a correct explanation for Statement–1.

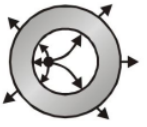
(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Q37. A metallic shell has a point charge 'q' kept inside its cavity. Which one of the following diagrams correctly represents the electric lines of forces :-

(A) 

(B) 

(C) 

(D)

Q38. A spherical portion has been removed from a solid sphere having a charge distributed uniformly in its volume in the figure. The electric field inside the emptied space is :-

(A) Zero everywhere

(B) Non-zero and uniform

(C) Non-uniform

(D) Zero only at its center

Miscellaneous

Q39. Under the influence of the electric field of charge +Q, a charge –q is moving around it in an elliptical orbit. Find out the correct statement(s) :-

(A) The angular momentum of the charge –q is constant

(B) The linear momentum of the charge –q is constant

(C) The angular velocity of the charge –q is constant

(D) The linear speed of the charge –q is constant

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A particle of mass m and charge q is thrown in a region where uniform gravitational field and electric field are present. The path of particle :

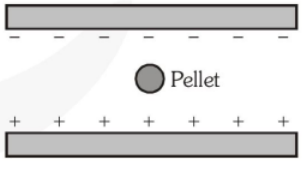
(A) May be a straight line

(B) May be a circle

(C) May be a parabola

(D) May be a hyperbola

Q2. A tiny charged pellet of mass *m* is suspended at rest by the electric field between two horizontal, charged metallic plates. The lower plate has a positive charge and the upper plate has a negative charge. Which statement in the answers here is/are true ?



(A) The electric field between the plates points vertically upward.

(B) The pellet is negatively charged.

(C) The magnitude of the electric force on the pellet is equal to *mg*.

(D) If the magnitude of charge on the plates is increased, the pellet begins to move upward.

Q3. If the flux of the electric field through a closed surface is zero,

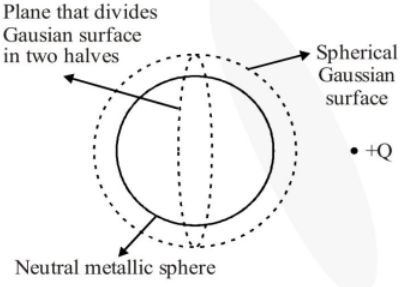
(A) The electric field must be zero everywhere on the surface

(B) The electric field may be zero everywhere on the surface

(C) The net charge inside the surface must be zero

(D) The net charge in the vicinity of the surface must be zero.

Q4. Figure shows a neutral metallic sphere with a point charge +Q placed near its surface. Electrostatic equilibrium conditions exist on metallic sphere. Mark the correct statements:



(A) Net flux through Gaussian surface due to charge Q is zero.

(B) Net flux through Gaussian surface due to charges appearing on the outer surface of metallic sphere must be zero.

(C) If point charge Q is displaced towards metallic sphere, magnitude of net flux through right hemispherical closed Gaussian surface increases.

(D) If point charge Q is displaced towards metallic sphere, charge distribution on outer surface of sphere will change.

Q5. A hollow closed conductor of irregular shape is given some charge. Which of the following statements are correct ?

(A) The entire charge will appear on its outer surface.

(B) All points on the conductor will have the same potential.

(C) All points on its surface will have the same charge density.

(D) All points just outside it will have the same electric intensity.

Q6. In the statement of Gauss's law :

$$\oint\!\!\oint \vec{E}.d\vec{s} = \frac{q_{enclosed}}{\epsilon_0}$$

Select the correct alternative(s) :

(A) The value of $\oint\!\!\oint \vec{E}.d\vec{s}$ does not depend on the shape of gaussian surface if it encloses same charge.

(B) The electric field $\vec{E}$ also includes the contribution of charges outside the gaussian surface.

(C) If charge is moved inside the gaussian surface $\vec{E}.d\vec{s}$ at any point on surface remains constant.

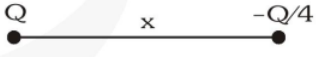
(D) If charge is moved inside the gaussian surface electric field at every point on surface may change but $\oint\!\!\oint \vec{E}.d\vec{s}$ remains unchanged.

Q7. A particle of charge 1μC & mass 1 gm moving with a velocity of 4 m/s is subjected to a uniform electric field of magnitude 300 V/m for 10 sec. Then it's final speed cannot be :

(A) 0.5 m/s (B) 4 m/s

(C) 3 m/s (D) 6 m/s

Q8. Two point charges Q and –Q/4 are separated by a distance x. Then :



(A) Potential is zero at a point on the axis which is at a distance x/3 on the right side of the charge–Q/4

(B) Potential is zero at a point on the axis which is at a distance x/5 on the left side of the charge–Q/4

(C) Electric field is zero at a point on the axis which is at a distance x on the right side of the charge–Q/4

(D) There exist two points on the axis where electric field is zero

Q9. Four charges of 1μC, 2μC, 3μC, and – 6μC are placed one at each corner of the square of side 1m. The square lies in the x–y plane with its centre at the origin.

(A) The electric potential is zero at the origin.

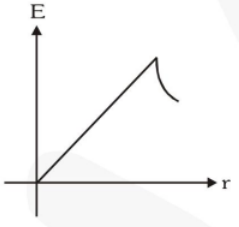
(B) The electric potential is zero everywhere along the x–axis only if the sides of the sqaure are parallel to x and y axis.

(C) The electric potential is zero everywhere along the z–axis for any orientation of the square in the x–y plane.

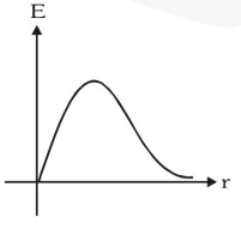
(D) The electric potential is not zero along the z–axis except at the origin.

Q10. A circular ring carries a uniformly distributed positive charge. The electric field (E) and potential (V) varies with distance (r) from the centre of the ring along its axis as :

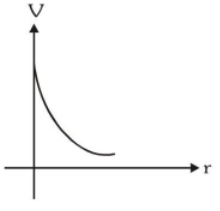
(A)



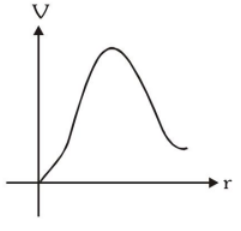
(B)



(C)



(D)



Q11. Which of the following is true for the figure showing electric lines of force?

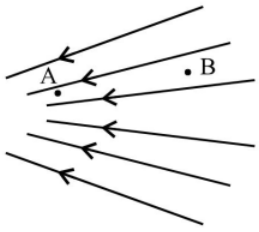
(E is electrical field, V is potential)

(A) $E_A > E_B$

(B) $E_B > E_A$

(C) $V_A > V_B$

(D) $V_B > V_A$



Q12. The electric potential decreases uniformly from V to –V along X–axis in a coordinate system as we moves from a point $(-x_0, 0)$ to $(x_0, 0)$, then the electric field at the origin :

(A) must be equal to $\frac{V}{x_0}$

(B) may be equal to $\frac{V}{x_0}$

(C) must be greater than $\frac{V}{x_0}$

(D) may be less than $\frac{V}{x_0}$

Q13. A uniform electric field pointing in positive x–direction exists in a region. Let A be the origin, B be the point on the x–axis at x = +1 cm and C be the point on the y–axis at y = +1cm. Then the potentials at the A, B and C satisfy :

(A) $V_A < V_B$ (B) $V_A > V_B$

(C) $V_A < V_C$ (D) $V_A > V_C$

Q14. Equipotential surfaces :-

(A) Are closer in regions of large electric fields compared to regions of lower electric fields.

(B) Will be more crowded near sharp edges of a conductor.

(C) Will be more crowded near regions of large charge densities.

(D) Will always be equally spaced.

Q15. An electric dipole is placed in an electric field generated by a point charge –

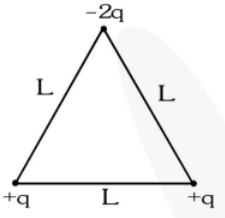
(A) The net electric force on the dipole must be zero.

(B) The net electric force on the dipole may be zero.

(C) The torque on the dipole due to the field must be zero.

(D) The torque on the dipole due to the field may be zero.

Q16. Three points charges are placed at the corners of an equilateral triangle of side L as shown in the figure:



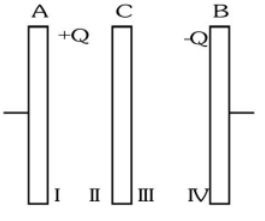
(A) The potential at the centroid of the triangle is zero.

(B) The electric field at the centroid of the triangle is zero.

(C) The dipole moment of the system is $\sqrt{2}$ qL.

(D) The dipole moment of the system is $\sqrt{3}$ qL.

Q17. Plates A and B constitutes an isolated, charge parallel plate capacitor. The inner surfaces (I and IV) of A and B have charges + Q and –Q respectively. A third plate C with charge + Q is now introduced midway between A and B. Which of the following statements is not correct?



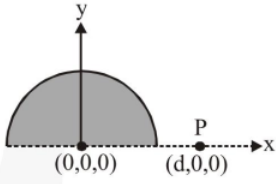
(A) The surface I and II will have equal and opposite charges.

(B) The surfaces III and IV will have equal and opposite charges.

(C) The charge on surace III will be greater than Q.

(D) The potential difference between A and C will be equal to the potential difference between C and B.

Q18. A solid hemispherical uniform charged body having charge Q is kept symmetrically along the y-axis as shown in figure. The electric potential at a distance d from the origin along the x-axis at point P will be-



(A) $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d}$

(B) Less than $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d}$

(C) More than $\frac{1}{4\pi\varepsilon_0}\frac{Q}{d}$ and less then $\frac{2}{4\pi\varepsilon_0}\frac{Q}{d}$

(D) More than $\frac{2}{4\pi\varepsilon_0}\frac{Q}{d}$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

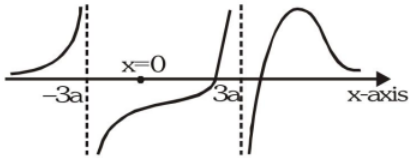
Paragraph for Question No. 19 & 20

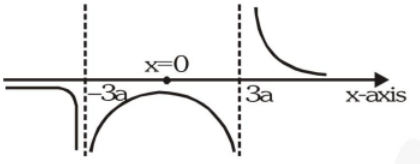
Electric potential is a scalar quantity. Due to a point charge q at distance r, the potential is given by $V = \frac{q}{4\pi\in_0 r}$. A point charge q is placed at (3a, 0) and another charge –2q is placed at (–3a 0).

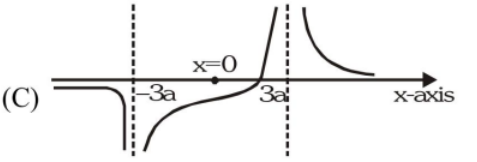
Q19. At how many points on the x–axis, (at finite distance) electric potential will be zero ?

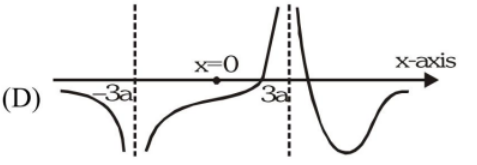
(A) 1 (B) 2 (C) 3 (D) 4

Q20. If we plot a graph of potential (V) on x–axis it will be like :

(A) 

(B) 

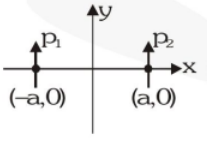
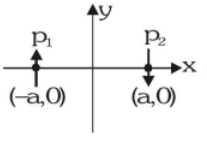
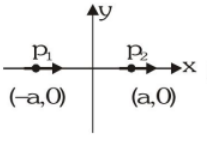
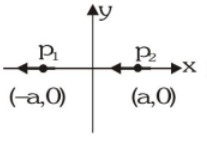
(C) 

(D) 

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q21. In each situation of column–I, two electric dipoles having dipole moments $\vec{p}_1$ and $\vec{p}_2$ of same magnitude (that is, $p_1 = p_2$) are placed on x–axis symmetrically about origin in different orientations as shown. In column–II certain inferences are drawn for these two dipoles. Then match the different orientations of dipole in column–I with the corresponding results in column–II.

Column I	**Column II**
(A)  ($\vec{p}_1$ and $\vec{p}_2$ are perpendicular to x–axis as shown)	(P) The torque on one dipole due to other is zero.
(B)  ($\vec{p}_1$ and $\vec{p}_2$ are perpendicular to x–axis as shown)	(Q) The potential energy of one dipole in electric field of other dipole is negative
(C)  ($\vec{p}_1$ and $\vec{p}_2$ are parallel to x–axis as shown)	(R) There is one straight line in x-y plane (not at infinity) which is equipotential
(D)  ($\vec{p}_1$ and $\vec{p}_2$ are parallel to x–axis as shown)	(S) Electric field at origin is zero.

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

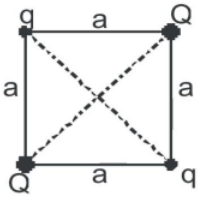
Q22. Consider $\vec{E} = 3 \times 10^3 \hat{i}$ (N/C) then what is the flux through the square of 10 cm side, if the normal of its plane makes a 60° angle with the X axis.

SUBJECTIVE TYPE

Q23. When a piece of polythene is rubbed with wool, a charge of -2×10^{-7} C is developed on polythene. What is the amount of mass, which is transfered to polythene.

Q24. Find the electric field due to an infinitely long cylindrical charge distribution of radius R and having linear charge density λ at a distance half of the radius from its axis.

Q25. For the system shown in figure find Q for which resultant force on q is zero :-

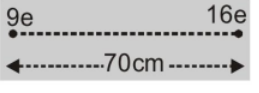


Exercise - 2 Brain Booster

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Two charges are placed as shown in figure. Where should be a third charge be placed so that it remains in rest condition:-



(A) 30cm from 9e (B) 40cm from 16e
(C) 40cm from 9e (D) (A) and (B) Both

Q2. A charge Q is divided in two parts Q_1 and Q_2 and these charges are placed at a distance R. There will be maximum repulsion between them when :-

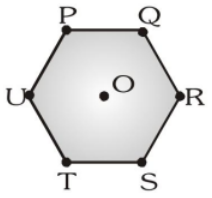
(A) $Q_1 = \frac{Q-Q}{R}, Q_2 = \frac{Q}{R}$

(B) $Q_1 = \frac{2Q}{3}, Q_2 = \frac{Q}{3}$

(C) $Q_1 = \frac{3Q}{4}, Q_2 = \frac{Q}{4}$

(D) $Q_1 = Q_2 = \frac{Q}{2}$

Q3. Six charges, three positive and three negative of equal magnitude are to be placed starts from P in clockwise order at the vertices of a regular hexagon such that the electric field at O is double the electric field when only one positive charge of same magnitude is placed at R. Which of the following arrangements of charge is possible for, P, Q, R, S, T and U respectively ?



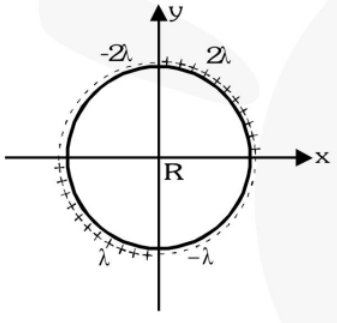
(A) +, –, +, –, –, + (B) +, –, +, –, +, –
(C) +, +, –, +, –, – (D) –, +, +, –, +, –

Q4. A ring of radius R is charged uniformly with a charge + Q . The electric field at any point on its axis at a distance r from the circumference of the ring will be :-

(A) $\frac{KQ}{r}$ (B) $\frac{KQ}{r^2}$

(C) $\frac{KQ}{r^3}\left(r^2-R^2\right)^{1/2}$ (D) $\frac{KQr}{R^3}$

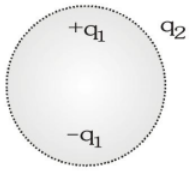
Q5. The charge per unit length of the four quadrant of the ring is 2λ, -2λ, λ and $-\lambda$ respectively. The electric field at the centre is :



(A) $\frac{-\lambda}{2\pi\varepsilon_0 R}\hat{i}$ (B) $\frac{\lambda}{2\pi\varepsilon_0 R}\hat{j}$

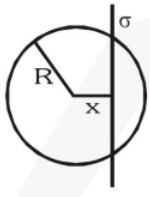
(C) $\frac{\sqrt{2}\lambda}{4\pi\varepsilon_0 R}\hat{i}$ (D) None

Q6. Consider the charge configuration and a spherical Gaussian surface as shown in the figure. When calculating the flux of the electric field over the spherical surface, the electric field will be due to:



(A) q_2
(B) only the positive charges
(C) all the charges
(D) $+q_1$ and $-q_1$

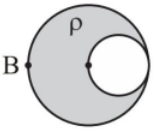
Q7. An infinite, uniformly charged sheet with surface charge denisty σ cuts through a spherical Gaussian surface of radius R at a distance x from its center, as shown in the figure. The electric flux ϕ through the Gaussian surface is :



(A) $\frac{\pi R^2\sigma}{\varepsilon_0}$ (B) $\frac{2\pi\left(R^2-x^2\right)\sigma}{\varepsilon_0}$

(C) $\frac{\pi\left(R-x\right)^2\sigma}{\varepsilon_0}$ (D) $\frac{\pi\left(R^2-x^2\right)\sigma}{\varepsilon_0}$

Q8. A positively charged sphere of radius r_0 carries a volume charge density ρ (Figure). A spherical cavity of radius $r_0/2$ is then scooped out and left empty, as shown. What is the direction and magnitude of the electric field at point B ?



(A) $\frac{17\rho r_0}{54\,\epsilon_0}$ left (B) $\frac{\rho r_0}{6\,\epsilon_0}$ left

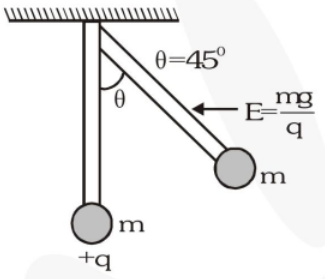
(C) $\frac{17\rho r_0}{54\,\epsilon_0}$ right (D) $\frac{\rho r_0}{6\,\epsilon_0}$ right

Q9. A sphere of radius R carries charge density proportional to the square of the distance from the center: $\rho = Ar^2$, where A is a positive constant. At a distance of R/2 from the center, the magnitude of the electric field is -

(A) $A/4\pi\varepsilon_0$ (B) $AR^3/40\varepsilon_0$

(C) $AR^3/24\varepsilon_0$ (D) $AR^3/5\varepsilon_0$

Q10. A horizontal electric field (E = mg/q) exists as shown in figure and a mass m attached at the end of a light rod. If mass m is released from the position shown in figure, find the angular velocity of the rod when it passes through the bottom most position :



(A) $\sqrt{\frac{g}{\ell}}$ (B) $\sqrt{\frac{2g}{\ell}}$

(C) $\sqrt{\frac{3g}{\ell}}$ (D) $\sqrt{\frac{5g}{\ell}}$

Q11. In an electrostatic field, a point charge is taken from A to B such that external work done on it is W_1 and its kinetic energy increases by K_1. In the same field the same charge is taken from A to C such that work done by electrostatic field on it is W_2 and its kinetic energy increase by K_2. Find the external work done on the charge if it is taken from B to C without changing K.E.

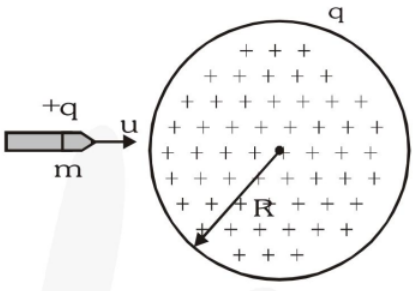
(A) $W_2 + W_1 - K_1$

(B) $K_1 - W_2 - W_1$

(C) $W_1 - W_2 + K_2 - K_1$

(D) $W_2 - W_1 + K_1 - K_2$

Q12. A bullet of mass m and charge q is fired towards a solid uniformly charged sphere of radius R and total charge + q. If it strikes the surface of sphere with speed u, find the minimum value of u so that it can penetrate through the sphere. (Neglect all resistnace forces or friction acting on bullet except electrostatic forces)



(A) $\frac{q}{\sqrt{2\pi\varepsilon_0 mR}}$ (B) $\frac{q}{\sqrt{4\pi\varepsilon_0 mR}}$

(C) $\frac{q}{\sqrt{8\pi\varepsilon_0 mR}}$ (D) $\frac{\sqrt{3}q}{\sqrt{4\pi\varepsilon_0 mR}}$

Q13. The electrostatic potential on the surface of a charged conducting solid sphere is 100V. Two statements are made in this regard:

S_1 : At any point inside the sphere, electric intensity is zero.

S_2 : At any point inside the sphere, the electrostatic potential is 100V.

Which of the following is a correct statement?

(A) S_1 is true but S_2 is false.

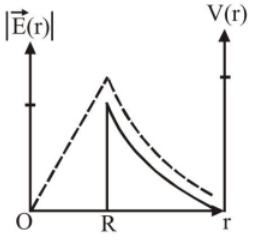
(B) Both S_1 & S_2 are false.

(C) S_1 is true, S_2 is also true and S_1 is the cause of S_2.

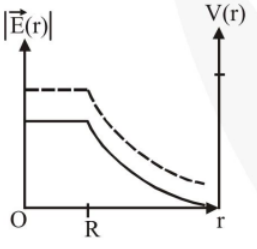
(D) S_1 is true, S_2 is also true but the statements are independent.

Q14. Consider a thin conducting spherical shell of radius R with its centre at the origin, carrying uniform positive surface charge density. The variation of the magnitude of the electric field $|\vec{E}(r)|$ and the electric potential V(r) with the distance r from the centre, is best represented by which graph:

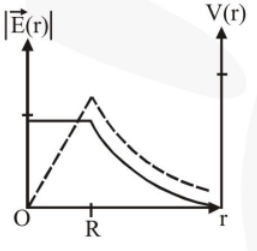
(A)



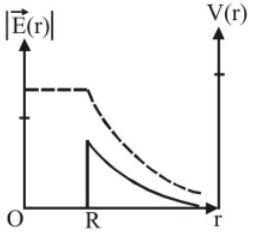
(B)



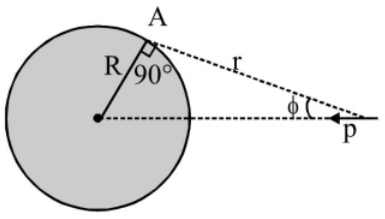
(C)



(D)



Q15. A dipole having dipole moment p is placed in front of a solid uncharged conducting sphere as shown in the diagram. The net potential at point A lying on the surface of the sphere is



(A) $\frac{kp\cos\phi}{r^2}$ (B) $\frac{kp\cos^2\phi}{r^2}$

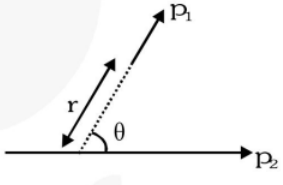
(C) $\frac{2kp\cos^2\phi}{r^2}$ (D) zero

Q16. A small electric dipole is of dipole moment p. The electric potential at a distance 'r' from its centre and making an angle θ from the axis of dipole will be:-

(A) $\frac{kp\sin\theta}{r^2}$ (B) $\frac{kp\cos\theta}{r^2}$

(C) $\frac{kp}{r^3}\sqrt{1+3\cos^2\theta}$ (D) $\frac{kp}{r^3}\sqrt{1+3\sin^2\theta}$

Q17. Two short electric dipoles are placed as shown. The energy of electric interaction between these dipoles will be :



(A) $\frac{2Kp_1p_2\cos\theta}{r^3}$ (B) $\frac{-2Kp_1p_2\cos\theta}{r^3}$

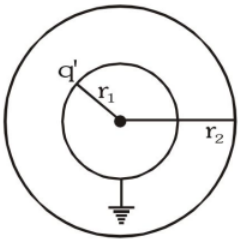
(C) $\frac{-2Kp_1p_2\sin\theta}{r^3}$ (D) $\frac{-4Kp_1p_2\cos\theta}{r^3}$

Q18. If n drops of equal size and same potential V are converted into a bigger drop then the potential of bigger drop will be :–

(A) $\frac{V}{n}$ (B) Vn

(C) $Vn^{1/3}$ (D) $Vn^{2/3}$

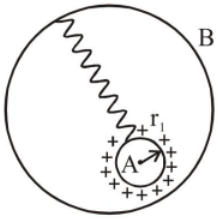
Q19. The concentric conducting spheres are of radii r_1 and r_2. The outer sphere is given a charge q. The charge q′ on the inner sphere will be (inner sphere is grounded):



(A) q (B) -q

(C) $-q\frac{r_1}{r_2}$ (D) Zero

Q20. A metal sphere A of radius r_1 charged to a potential ϕ_1 is enveloped by a thin walled conducting spherical shell B of radius r_2. Then ϕ_2 of the sphere A after it is connected by a thin conducting wire to the shell B will be:



(A) $\phi_1\left(\frac{r_1}{r_2}\right)$ (B) $\phi_1\left(\frac{r_2}{r_1}\right)$

(C) $\phi_1\left(1-\frac{r_2}{r_1}\right)$ (D) $\phi_1\left(\frac{r_1 r_2}{r_1+r_2}\right)$

Exercise - 2A Brain Booster

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A charged particle having some mass is resting in equilibrium at a height H above the centre of a uniformly charged non-conducting horizontal ring of radius R. The force of gravity acts downwards. The equilibrium of the particle will be stable.

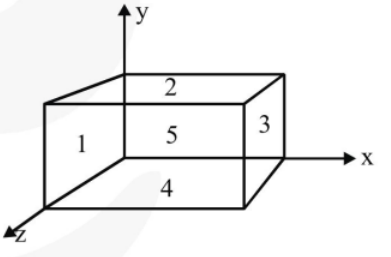
(A) for all values of H

(B) only if $H > \frac{R}{\sqrt{2}}$

(C) only if $H < \frac{R}{\sqrt{2}}$

(D) only if $H = \frac{R}{\sqrt{2}}$

Q2. In a region of space, the electric field $\vec{E} = E_0 x\hat{i} + E_0 y\hat{j}$. Consider an imaginary cubical volume of edge 'a' with its edges parallel to the axes of coordinates. Now,



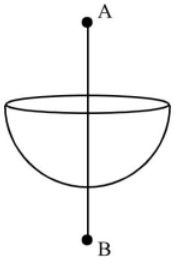
(A) the total electric flux through the faces 1 and 3 is E_0a^3

(B) the charge inside the cubical volume is $2\varepsilon_0E_0a^3$

(C) the total electric flux through the faces 2 and 4 is $2E_0a^3$

(D) the charge inside the cubical volume is $\varepsilon_0E_0a^3$

Q3. The diagram shows a uniformly charged hemisphere of radius R. It has volume charge density ρ. If the electric field at a point 2R distance above its center is E then what is the electric field at the point which is 2R below its center?



(A) $\rho R/6\varepsilon_0 + E$ (B) $\rho R/12\varepsilon_0 - E$
(C) $-\rho R/6\varepsilon_0 + E$ (D) $\rho R/24\varepsilon_0 + E$

Q4. Mark the correct option(s) :

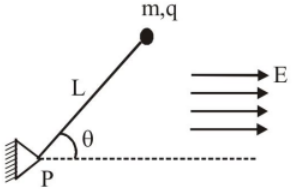
(A) Gaussian surface can pass through discrete charge.

(B) Gaussian surface can be of any shape.

(C) The electric field calculated by Gauss's law is the field only due to the charges inside the Gaussian surface.

(D) The flux of the electric field through a closed surface due to all the charges is equal to the flux due to the charges enclosed by the surface.

Q5. A particle of mass m and charge q is attached to a light rod of length L. The rod can rotate freely in the plane of paper about the other end, which is hinged at P. The entire assembly lies in a uniform electric field E also acting in the plane of paper as shown. The rod is released from rest when it makes an angle θ with the electric field direction. Determine the speed of the particle when the rod is parallel to the electric field.



(A) $\left(\frac{2qEL(1-\cos\theta)}{m}\right)^{1/2}$

(B) $\left(\frac{2qEL(1-\sin\theta)}{m}\right)^{1/2}$

(C) $\left(\frac{qEL(1-\cos\theta)}{2m}\right)^{1/2}$

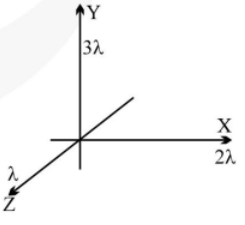
(D) $\left(\frac{2qEL\cos\theta}{m}\right)^{1/2}$

Q6. A charged particle of charge Q is held fixed and another charged particle of mass m and charge q (of the same sign) is released from a distance r. The impulse of the force exerted by the external agent on the fixed charge by the time distance between Q and q becomes 2r is -

(A) $\sqrt{\frac{Qq}{4\pi\epsilon_0 mr}}$ (B) $\sqrt{\frac{Qqm}{4\pi\epsilon_0 r}}$

(C) $\sqrt{\frac{Qqm}{\pi\epsilon_0 r}}$ (D) $\sqrt{\frac{Qqm}{2\pi\epsilon_0 r}}$

Q7. The diagram shows three infinitely long uniform line charges placed on the X, Y and Z axis. The work done in moving a unit positive charge from (1, 1, 1) to (0, 1, 1) is equal to -



(A) $\frac{\lambda \ln 2}{2\pi\varepsilon_o}$ (B) $\frac{\lambda \ln 2}{\pi\varepsilon_o}$

(C) $\frac{3\lambda \ln 2}{2\pi\varepsilon_o}$ (D) None

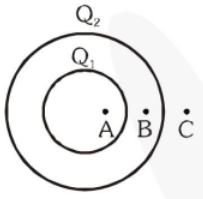
Q8. In an electric field the potential at a point is given by the following relation $V = \frac{343}{r}$.

The electric field at $\vec{r} = 3\hat{i} + 2\hat{j} + 6\hat{k}$ is :

(A) $21\hat{i} + 14\hat{j} + 42\hat{k}$ (B) $3\hat{i} + 2\hat{j} + 6\hat{k}$

(C) $\frac{1}{7}\left(3\hat{i} + 2\hat{j} + 6\hat{k}\right)$ (D) $-\left(3\hat{i} + 2\hat{j} + 6\hat{k}\right)$

Q9. Figure shows two uniform charged concentric spherical shell. Both charges are positive, Select correct statement :



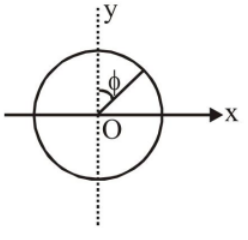
(A) Electric field intensity at B may be greater than electric field intensity at C.

(B) Electric field intensity at B must be greater than electric field intensity at C.

(C) Potential at A greater than potential at B

(D) If a charge moves from B to C work done by electric force must be positive.

Q10. A thin non-conducting ring of radius a has a linear charge density $\lambda = \lambda_0 \sin\phi$. A uniform electric field $E_0\hat{i} + E_0\hat{j}$ is present there. Net torque acting on ring is -



(A) $E_0\sqrt{2}\pi a^2\lambda_0$ (B) $E_0\pi a^2\lambda_0$

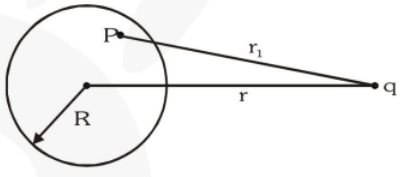
(C) $2E_0\pi a^2\lambda_0$ (D) zero

Q11. Two non-conducting hemispherical surfaces, which are having uniform charge density σ are placed on smooth horizontal surface as shown in figure. Assuming springs are ideal, calculate compression in each spring if both the hemispherical surface are just touching each other.

(A) $\frac{\sigma^2R^2}{2\varepsilon_0 k}$ (B) R

(C) $\frac{\sigma^2\pi R^2}{2\varepsilon_0 k}$ (D) None of these

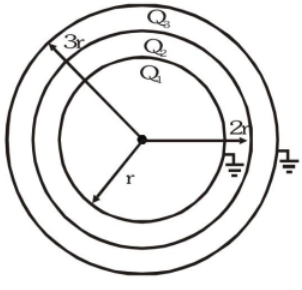
Q12. A point charge q is placed at a distance r from center of a conducting neutral sphere of radius R (r>R). The potential at any point P inside the sphere at a distance r_1 from point charge due to induced charge of the sphere is given by-



(A) $\frac{Kq}{r_1} - \frac{Kq}{R}$ (B) $\frac{Kq}{r_1} - \frac{Kq}{R}$

(C) $\frac{Kq}{r} - \frac{Kq}{r_1}$ (D) $-\frac{Kq}{r_1} + \frac{Kq}{R}$

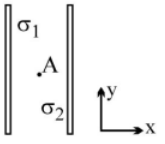
Q13. Three concentric conducting spherical shells have radius r, 2r and 3r and Q_1, Q_2 and Q_3 are final charges respectively. Innermost and outermost shells are already earthed as shown in figure. choose the wrong statement.



(A) $Q_1 + Q_3 = -Q_2$ (B) $Q_1 = \frac{-Q_2}{4}$

(C) $\frac{Q_3}{Q_1} = 3$ (D) $\frac{Q_3}{Q_2} = \frac{-1}{3}$

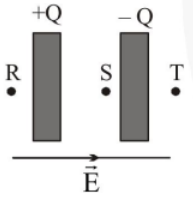
Q14. Two large conducting sheets are kept parallel to each other as shown. In equilibrium, the charge density on facing surfaces is σ_1 and σ_2. What is the value of electric field at A.



(A) $\frac{\sigma_1}{\varepsilon_0}\hat{i}$ (B) $-\frac{\sigma_2}{\varepsilon_0}\hat{i}$

(C) $\frac{\sigma_1+\sigma_2}{2\varepsilon_0}\hat{i}$ (D) $\frac{\sigma_1-\sigma_2}{2\varepsilon_0}\hat{i}$

Q15. Two large thin conducting plates with small gap in between are placed in a uniform electric field E (perpendicular to the plates). Area of each plate is A and charges +Q and –Q are given to these plates as shown in the figure. If points R,S and T as shown in the figure are three points in space, then the



(A) Field at point R is E

(B) Field at point S is E

(C) Field at point T is $\left(E+\frac{Q}{\varepsilon_o A}\right)$

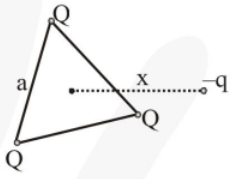
(D) Field at point S is $\left(E+\frac{Q}{A\varepsilon_o}\right)$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Q. No. 16 to 18

Three charged particles each of +Q are fixed at the corners of an equilateral triangle of side 'a'. A fourth particle of charge –q and mass m is placed at a point on the line passing through centroid of triangle and perpendicular to the plane of triangle at a distance x from the centre of triangle.



Q16. Magnitude of resultant force on the fourth charged particle is

(A) $\frac{1}{4\pi\epsilon_0}\frac{9\sqrt{3}\ Qqx}{(3x^2+a^2)^{3/2}}$

(B) $\frac{1}{4\pi\epsilon_0}\frac{27\sqrt{3}\ Qqx}{(3x^2+a^2)^{3/2}}$

(C) $\frac{1}{4\pi\epsilon_0}\frac{2\sqrt{2}\ Qqx}{(2x^2+a^2)^{3/2}}$

(D) $\frac{1}{4\pi\epsilon_0}\frac{4\sqrt{2}\ Qqx}{(2x^2+a^2)^{3/2}}$

Q17. Value of x for which the force is maximum is

(A) $\frac{a}{\sqrt{3}}$ (B) $\frac{a}{\sqrt{2}}$

(C) $\frac{a}{\sqrt{6}}$ (D) $\frac{a}{\sqrt{5}}$

Q18. For small oscillation the period of oscillation of fourth particle is

(A) $2\pi\sqrt{\frac{4\pi\epsilon_0 ma^3}{9\sqrt{3}Qq}}$

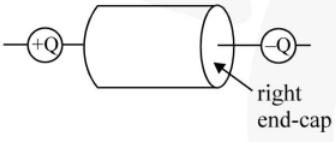
(B) $\pi\sqrt{\frac{4\pi\epsilon_0 ma^3}{9\sqrt{3}Qq}}$

(C) $2\pi\sqrt{\frac{2\pi\epsilon_0 ma^3}{27\sqrt{3}Qq}}$

(D) $2\pi\sqrt{\frac{\pi\epsilon_0 ma^3}{27\sqrt{3}Qq}}$

Paragraph for Question No. 19 & 20

The figure applies to the following two questions. Positive and negative charges of equal magnitude lie along the symmetry axis of a cylinder. The distance from the positive charge to the left end-cap of the cylinder is the same as the distance from the negative charge to the right end -cap.



Q19. What is the flux of the electric field through the closed cylinder ?

(A) 0 (B) $+ Q / \varepsilon_0$

(C) $+ 2Q / \varepsilon_0$ (D) $- Q / \varepsilon_0$

Q20. What is the sign of the flux through the right end-cap of the cylinder ?

(A) Positive

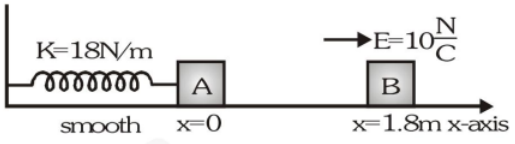
(B) Negative

(C) There is no flux through the right end-cap.

(D) None of these

Paragraph for Question No. 21 to 23

Electrostatic force on a charged particle is given by $\vec{F} = q\vec{E}$. If q is positive $\vec{F} \uparrow\uparrow \vec{E}$ and if q negative $\vec{F} \uparrow\downarrow \vec{E}$. In the figure $m_A = m_B = 1kg$. Block A is neutral while $q_B = -1C$. Sizes of A and B are negligible. B is released from rest at a distance 1.8 m from A. Initially spring is neither compressed nor elongated.



Q21. If collision between A and B is perfectly inelastic, what is velocity of combined mass just after collision ?

(A) 6m/s (B) 3m/s

(C) 9m/s (D) 12m/s

Q22. Equilibrium position of the combined mass is at x = ...m.

(A) $-\frac{2}{9}$ (B) $-\frac{1}{3}$

(C) $-\frac{5}{9}$ (D) $-\frac{7}{9}$

Q23. The amplitude of oscillation of the combined mass will be :–

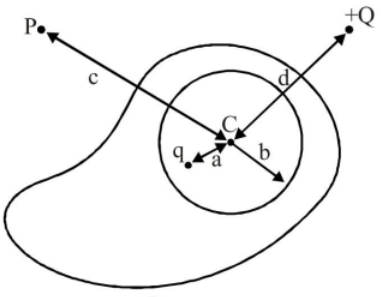
(A) $\frac{2}{3}$m (B) $\frac{\sqrt{124}}{3}$m

(C) $\frac{\sqrt{72}}{9}$m (D) $\frac{\sqrt{106}}{9}$m

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q24. In the shown figure the conductor is uncharged and a charge q is placed inside a spherical cavity at a distance a from its centre (C). Point P and charge $+Q$ are as shown. a, b, c, d are known.



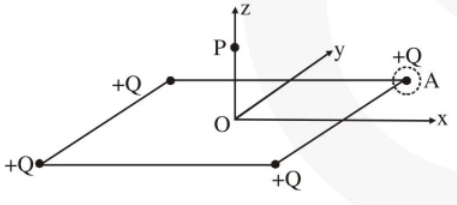
Column-I	**Column-II**
(A) Electric field due to induced charges on the inner surface of cavity at point P	(P) zero
(B) Electric potential due to charges on the inner surface of cavity and q at P	(Q) non-zero
(C) Electric field due to induced charges on the outer surface of conductor and Q at C	(R) value can be stated with the given data.
(D) Electric potential due to induced charges on the inner surface of cavity at C	(S) value cannot be stated from the given data.

Q25. Column I shows certain charge configurations in x-y plane. Resultant field is $\vec{E} = E_x\hat{i} + E_y\hat{j} + E_2\hat{k}$.

If a component points along positive x-axis it is conventionally positive i.e. $E_x > 0$ implies x component is along positive x-axis. Point O is equidistant from all charges.

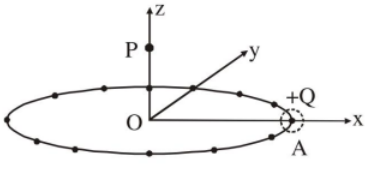
Column-I

(A)



Four point charges placed at the vertex of a square

(B)



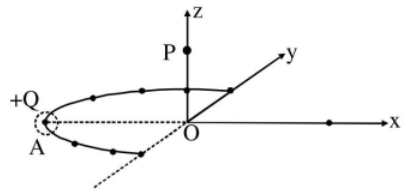
N (even number more than 6) identical point charges are placed symmetrically on a non-conducting ring.

Column-II

(P) Resultant field at P has
$E_x = 0$
$E_y = 0$
$E_z \neq 0$

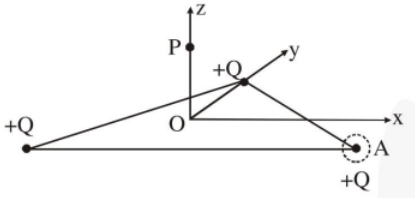
(Q) Resultant field at O has
$E_x = E_y = E_z = 0$

(C)



N (is odd number more than 5) identical point charges are placed symmetrically on a non-conducting semi-circular ring.

(D)



Three charges are placed on the vertex of an equilateral triangle. Point O is centroid of triangle.

(R) If charge at A is removed, resultant field at P has
$E_z > 0$
$E_x > 0$
$E_y > 0$

(S) If charged at A is removed; resultant field at O has $E_x > 0$

(T) If charge at A becomes negative, resultant field at O
$E_x > 0$
$E_y > 0$

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	A	B	**D**	B	A	B	C	C	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	D	C	A	D	B	**B**	B	A	B
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	C	B	B	C	C	A	D	C	A
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	
C	**D**	**C**	**A**	**D**	**D**	**C**	**B**	A	

Ex-1A

1. A,C **2.** A,C,D **3.** B,C **4.** A,B,C,D **5.** A, B

6. A,B,D **7.** A **8.** A,B,C **9.** A,C **10.** B,C

11. A,D **12.** B **13.** B **14.** A,B,C **15.** D

16. A,D **17.** D **18.** A **19.** B **20.** D

21. A $\rightarrow$ (P,R) ; B $\rightarrow$ (P,Q,S); C $\rightarrow$ (P,Q); D $\rightarrow$ (P,Q)

22. $15 Nm^2/C$ **23.** 11.38×10^{-19} kg

24. $\frac{\lambda}{4\pi\epsilon_0 R}$ **25.** $q = -2\sqrt{2}Q$

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	D	D	C	A	C	D	A	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	B	C	D	B	B	B	D	C	A

Ex-2A

1. B **2.** A,B **3.** B **4.** B,D **5.** A

6. B **7.** B **8.** B **9.** A,C **10.** B

11. C **12.** C **13.** D **14.** A,B,D **15.** A,D

16. A **17.** C **18.** A **19.** A **20.** A

21. B **22.** C **23.** D

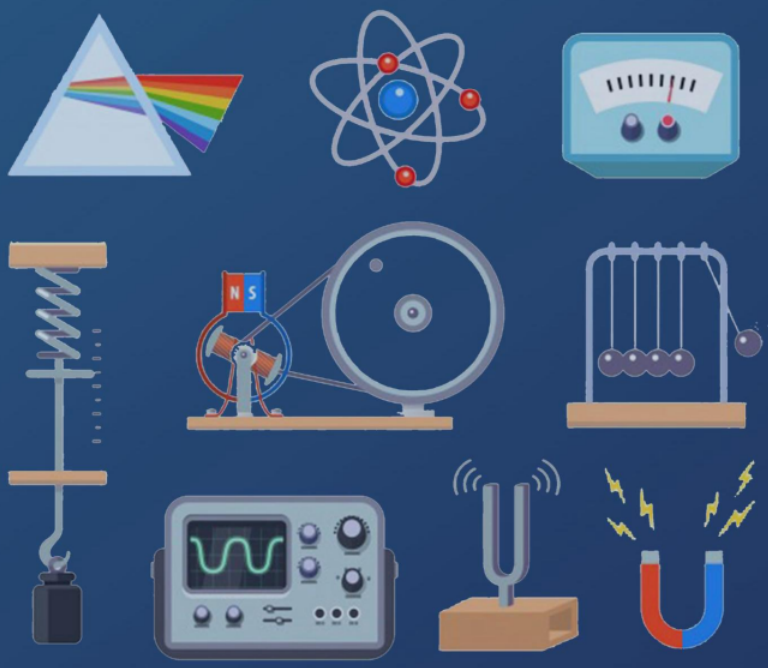
24. A $\rightarrow$ (Q,S) ; B $\rightarrow$ (P,R); C $\rightarrow$ (P,R); D $\rightarrow$ (Q,R)

25. A $\rightarrow$ (P,Q,R,S,T) ; B $\rightarrow$ (P,Q,S); C $\rightarrow$ (S); D $\rightarrow$ (P,Q,S)

-: Important Notes & Formulas :-

PHYSICS

Errors in Measurement



SHEET

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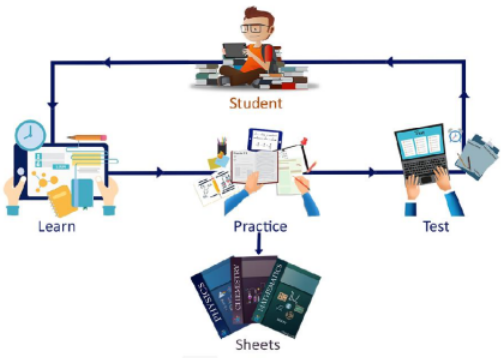
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Types of Errors	1			
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4	Vernier Callipers	11-15	1,3	5-7	1
5	Screw Gauge	16,17	4,8	8-11	2-5,14-16
6	Significant Digits	18-20	5-7	12-14	19-21
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Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Types of Errors

Q1. The mean time period of a simple pendulum is 1.92 s. Mean absolute error in the time period is 0.05 s. To express the maximum estimate of error, the time period should be written as–

(A) $T = (1.92 \pm 0.01)$ s

(B) $T = (1.92 \pm 0.025)$ s

(C) $T = (1.92 \pm 0.05)$ s

(D) $T = (1.92 \pm 0.10)$ s

Combination of Errors

Q2. A quantity is represented by $X = M^a L^b T^c$. The percentage error in measurement of M, L and T are α%, β % and γ % respectively. The percentage error in X would be :

(A) $(\alpha a + \beta b + \gamma c)$ %

(B) $(\alpha a - \beta b + \gamma c)$ %

(C) $(\alpha a - \beta b - \gamma c)$ %

(D) None of these

Q3. An experiment measures quantities a, b and c and X is calculated from $X = ab^2/c^3$. If the percentage error in a, b and c are $\pm 1\%$, $\pm 3\%$ and $\pm 2\%$ respectively, the percentage error in X will be :-

(A) $\pm 13\%$ (B) $\pm 7\%$

(C) $\pm 4\%$ (D) $\pm 1\%$

Q4. What is the fractional error in g calculated from $T = 2\pi\sqrt{\ell/g}$? Given that fractional errors in T and ℓ are $\pm x$ and $\pm y$ respectively.

(A) $x + y$ (B) $x - y$

(C) $2x + y$ (D) $2x - y$

Q5. A thin copper wire of length ℓ metre increases in length by 2% when heated through 10°C. What is the percentage increase in area when a square copper sheet of length ℓ metre is heated through 10°C ?

(A) 4%

(B) 8%

(C) 16%

(D) None of the above.

Q6. The resistance is $R = \frac{V}{I}$,

where $V = 100 \pm 5$ Volts

and $I = 10 \pm 0.2$ amperes.

What is the total error in R ?

(A) 5 % (B) 7 %

(C) 5.2 % (D) $\left(\frac{5}{2}\right)$ %

Q7. The length, breadth and thickness of a strip are (10.0 ± 0.1) cm, (1.00 ± 0.01)cm and (0.100 ± 0.001)cm respectively. The most probable error in its volume will be :

(A) ± 0.03 cm^3

(B) ± 0.111 cm^3

(C) ± 0.012 cm^3

(D) None of these

Q8. The percentage error in the measurement of mass and speed are 1% and 2% respectively. What is the percentage error in kinetic energy :-

(A) 5% (B) 2.5%

(C) 3% (D) 1.5%

Q9. If error in measuring diameter of a circle is 4 %, the error in circumference of the circle would be :-

(A) 2% (B) 8%

(C) 4% (D) 1%

Q10. The external and internal radius of a hollow cylinder are measured to be (4.23 ± 0.01) cm and (3.89 ± 0.01)cm. The thickness of the wall of the cylinder is :-

(A) (0.34 ± 0.02) cm

(B) (0.17 ± 0.02) cm

(C) (0.17 ± 0.01) cm

(D) (0.34 ± 0.01) cm

Vernier Caliper

Q11. In a vernier calliper, N divisions of vernier scale coincide with (N – 1) divisions of main scale (in which 1 division represents 1mm). The least count of the instrument in cm should be :

(A) N (B) N – 1

(C) $\frac{1}{10N}$ (D) $\frac{1}{N-1}$

Q12. One centimetre on the main scale of vernier callipers is divided into ten equal parts. If 10 divisions of vernier scale coincide with 8 small divisions of the main scale, the least count of the callipers is -

(A) 0.01 cm (B) 0.02 cm

(C) 0.05 cm (D) 0.005 cm

Q13. The zero error in a Vernier callipers is said to be positive when -

(A) zero of vernier scale is towards the right of the zero of main scale

(B) zero of vernier scale coincides with the zero of main scale

(C) zero of vernier scale is towards the left of the zero of main scale

(D) the vernier scale is not visible clearly.

Q14. Using upper pair of jaws of Vernier Callipers, we can measure :

(A) the depth of a cylindrical vessel

(B) the outer diameter of a vessel

(C) the inner diameter of a vessel

(D) the thickness of a thin wire

Q15. The zero error in a Vernier Callipers is said to be negative when -

(A) zero of Vernier Scale is towards right of the zero of main scale

(B) zero of Vernier scale coincides with the zero of main scale.

(C) zero of Vernier scale is towards left of the zero of main scale

(D) the Vernier scale is not visible clearly.

Screw gauge

Q16. A screw gauge has 1.0mm pitch and 200 divisions on the circular scale. The least count of the instrument is -

(A) 5×10^{-3} mm

(B) 5×10^{-4} mm

(C) 5×10^{-2} mm

(D) 5×10^{-5} mm

Q17. The circular scale of a screw gauge has 200 divisions. When it is given 4 complete rotations, it moves through 2mm. The least count of the screw gauge is -

(A) 0.25×10^{-2} cm

(B) 0.25×10^{-3} cm

(C) 0.001 cm

(D) 0.001 mm

Significant digits

Q18. How many significant figures are given in the following quantities ?

(a) 343 g (b) 2.20

(c) 1.103 N (d) 0.4142 s

(e) 0.0145 m (f) 1.0080 V

(g) 9.1×10^4 km (h) 1.124×10^{-3}V

(A) 24 (B) 26

(C) 28 (D)30

Q19. Which of the following option is correct for performing following operations :

(i) $703 + 7 + 0.66$ (ii) 2.21×0.3

(iii) 12.4×84 (iv) $14.28 / 0.714$

(A) 711, 0.7, 1.0×10^3, 20.0

(B) 0.7, 711, 1×10^3, 20

(C) 711, 20, 1×10^3, 0.7

(D) 711, 1×10^3, 0.7, 20

Q20. Solve with due regard to significant digits -

(i) $\sqrt{6.5 - 6.32}$ (ii) $\dfrac{2.91 \times 0.3842}{0.080}$

(A) 0.4, 14 (B) 0.4,13

(C) 0.3,14 (D) 0.3,13

After Full Chapter

Q21. The time period of a simple pendulum is given by $T = 2\pi\sqrt{\dfrac{\ell}{g}}$. In an experiment, the length of the pendulum is increased by 1%, while the acceleration due to gravity is also increased by 2%. The time period will –

Note :– It is talking of change & not error

(A) increase by 0.5%

(B) decrease by 0.5%

(C) increase by 1%

(D) decrease by 1%

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The nth division of main scale coincides with $(n + 1)^{th}$ division of vernier scale. Given one main scale division is equal to 'a' units. The least count of vernier is -

(A) $\dfrac{n}{a+1}$ (B) $\dfrac{a}{n+1}$

(C) an (D) $\dfrac{a}{n}$

Q2. In the Searle's experiment, after every step of loading , why should we wait for two minutes before taking the readings?

(A) So that the wire can have its desired change in length.

(B) So that the wire can attain room temperature.

(C) So that vertical oscillations can get subsided.

(D) So that the wire has no change in its radius.

SUBJECTIVE TYPE

Q3. One centimetre on the main scale of vernier callipers is divided into ten equal parts. If 20 divisions of vernier scale coincide with 19 small divisions of the main scale then what will be the least count of the callipers.

Q4. If the number of divisions on the circular scale is 100 and number of full rotations given to screw is 8 and distance moved by the screw is 4 mm, then what will be least count of the screw gauge.

Q5. Calculate area enclosed by a circle of diameter 1.06 m to correct number of significant figures.

Q6. Subtract 2.5×10^4 from 3.9×10^5 and give the answer to correct number of significant figures.

Q7. The original length of wire is (153.7 ± 0.6) cm. It is stretched to (155.3 ± 0.2) cm. Calculate the elongation in the wire with error limits.

NUMERICAL TYPE

Q8. The pitch of a screw gauge is 0.5 mm and there are 50 divisions on the circular scale. In measuring the thickness of a metal plate, there are five divisions on the pitch scale (or main scale) and thirty fourth division coincides with the reference line. Calculate the thickness of the metal plate in (mm).

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. The period of oscillation of a simple pendulum in the experiment is recorded as 2.63s, 2.56s, 2.42s, 2.71s and 2.80s respectively. The average absolute error is -

(A) 0.1s (B) 0.11s

(C) 0.01s (D) 1.0s

Q2. The length of a cylinder is measured with a metre rod having least count 0.1 cm. Its diameter is measured with vernier callipers having least count 0.01 cm. Given the length is 5.0 cm. and radius is 2.00 cm. The percentage error in the calculated value of volume will be –

(A) 2% (B) 1%

(C) 2.5% (D) 4%

Q3. The heat generated in a circuit is dependent upon the resistance, current and time for which the current is flown. If the error in measuring the above are as 1%, 2% and 1% the maximum error in measuring heat will be

(A) 2% (B) 3%

(C) 6% (D) 1%

Q4. A wire has a mass (0.3 ± 0.003)g, radius (0.5 ± 0.005) mm and length (6 ± 0.06) cm. The maximum percentage error in the measurement of its density is –

(A) 1 (B) 2

(C) 3 (D) 4

Q5. A vernier callipers has 20 divisions on the vernier scale which coincide with 19 divisions on the main scale. The least count of the instrument is 0.1 mm. The main scale divisions are of

(A) 0.5 mm (B) 1 mm

(C) 2 mm (D) 1/4 mm

Q6. The vernier constant of a vernier callipers is 0.1mm and it has a positive zero error of 0.04cm. While measuring diameter of a rod, the main scale reading is 1.2 cm and 5th vernier division is coinciding with any scale division. The correct diameter of the rod is-

(A) 1.21 cm (B) 1.21 mm

(C) 1.29 mm (D) 1.29 cm

Q7. 1 cm of main scale of a vernier calliper is divided into 10 divisions. The least count of the callipers is 0.05 cm, then the varnier scale must have :

(A) 10 divisions (B) 20 divisions

(C) 25 divisions (D) 50 divisions

Q8. A screw gauge gives the following reading when used to measure the diameter of a wire. Main scale reading = 0 mm, circular scale reading = 52 divisions. Given that 1mm on main scale corresponds to 100 divisions of the circular scale. The diameter of the wire from the above data is -

(A) 0.052 cm (B) 0.026 cm

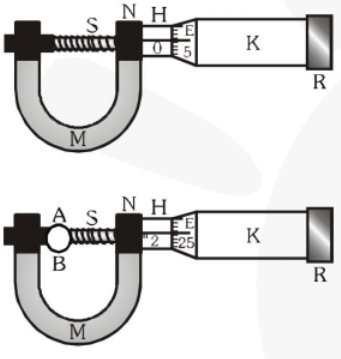
(C) 0.005 cm (D) 0.52cm

Q9. When a screw gauge is completely closed, zero of circular scale is 6 divisions below the reference line of graduation. If least count of screw gauge is 0.001 cm, the zero correction is -

(A) –0.006 cm (B) +0.006 cm

(C) –0.006 mm (D) +0.006 mm

Q10. The circular scale of a screw gauge has 50 divisions and pitch of 0.5mm. Find the diameter of sphere. Main scale reading is 2



(A) 1.20 mm (B) 1.25 mm

(C) 2.207 mm (D) 2.25 mm

Q11. A student measured the diameter of a wire using a screw gauge with least count 0.001 cm and listed the measurements. The correct measurement is -

(A) 5.3 cm (B) 5.32 cm

(C) 5.320 cm (D) 5.3200 cm

Q12. Least count of a vernier callipers is 0.01cm. Using this, the diameter of a sphere is measured as 1.95cm. Radius of the sphere to the correct significant figure will be :

(A) 0.98 cm (B) 0.975 cm

(C) 1.0 cm (D) 1 cm

Q13. Measure of two quantities along with the precision of respective measuring instrument is :-

A = 2.5 m/s ± 0.5 m/sB = 0.10s ± 0.01 s

The value of AB will be :-

(A) (0.25 ± 0.08) m

(B) (0.25 ± 0.5) m

(C) (0.25 ± 0.05) m

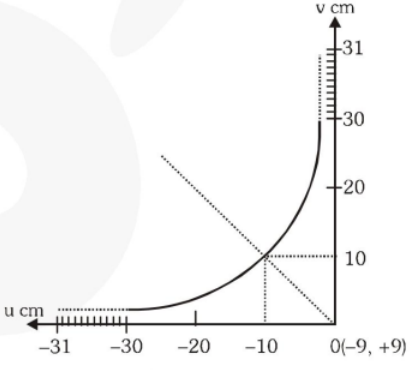
(D) (0.25 ± 0.135) m

Q14. The edge of a cube is $a = 1.2 \times 10^{-2}$ m. Then its volume will be recorded as :

(A) 1.7×10^{-6} m^3 (B) 1.70×10^{-6} m^3

(C) 1.70×10^{-7} m^3 (D) 1.78×10^{-6} m^3

Q15. Graph of position of image vs position of point object from a convex lens is shown. Then, focal length of the lens is -



(A) 0.50 ± 0.05 cm (B) 0.50 ± 0.10 cm

(C) 5.00 ± 0.05 cm (D) 5.00 ± 0.10 cm

Q16. An experiment is performed to find the refractive index of glass using a travelling microscope. In this experiment distances are measured by

(A) a vernier scale provided on the microscope

(B) a stanard laboratory scale

(C) a meter scale provided on the microscope

(D) a screw gauge provided on the microscope

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The least count of vernier callipers is 0.1mm. The main scale reading before the zero of the vernier scale is 10 and the zero th division of the vernier scale coincides with the main scale division. Given that each main scale division is 1 mm, the measured value should be expressed.

(A) 1 cm (B) 2 cm
(C) 0.5 cm (D) 0.1 cm

Q2. Two full turns of the circular scale of gauge cover a diastance of 1 mm on scale. The total number of divisions on circular scale is 50. Further, it is found that screw gauge has a zero error of -0.03 mm. While measuring the diameter of a thin wire a student notes the main scale reading of 3 mm and the number of circular scale division in line, with the main scale as 35. The diameter of the wire is-

(A) 3.32 mm (B) 3.73 mm
(C) 3.67 mm (D) 3.38 mm

Q3. When the gap is closed without placing any object in the screw gauge whose least count is 0.005 mm, the 5th division on its circular scale coincides with the reference line on main scale and when a small sphere is placed reading on main scale advances by 4 divisions, whereas circular scale reading advances by five times to the corresponding reading when no object was placed. There are 200 divisions on the circular scale. The radius of the sphere is -

(A) 4.10 mm (B) 4.05 mm
(C) 2.10 mm (D) 2.05 mm

Q4. While measuring diameter of a wire using a screw gauge the main scale reading is 7mm and zero of circular scale is 35 divisions above the reference line. If the screw gauge has a zero error of –0.003 cm, the correct diameter of the wire is

(given least count = 0.001cm)

(A) 0.735cm (B) 0.732cm
(C) 0.738 cm (D) 7.38 cm

Q5. On measuring diameter of a wire with help of screw gauge, main scale reading is 1 mm and 6th division of circular scale lying over reference line. On measuring zero error, it is found that zero of circular scale has advanced from reference line by 3 divisions on circular scale, then corrected diameter is-

(A) 1.09 mm (B) 1.06 mm
(C) 1.03 mm (D) 1.60 mm

Q6. A student obtained following observations in an experiment of meter bridge to find unknown resistance of given wire :

S.No.	R	ℓ	$100-\ell$	$S=\left(\frac{100-\ell}{\ell}\right)R$
1	2Ω	43	57	2.65
2	3Ω	52	48	2.77
3	4Ω	58	42	2.89
4	5Ω	69	31	2.25

The most accurate value of unknown resistance will be :

(A) 2.65 Ω (B) 2.77 Ω
(C) 2.89 Ω (D) 2.25 Ω

Q7. While measuring the speed of sound by performing a resonance column experiment, a student get's the first resonance condition at a column length of 18 cm during winter. Repeating the same experiment during summer, she measures the column length to be x cm for the second resonance. Then-

(A) $x > 54$ (B) $54 > x > 36$
(C) $36 > x > 18$ (D) $18 > x$

Q8. A student performs an experiment for determination of $\left(g=\frac{4\pi^2\ell}{T^2}\right)$, $\ell \approx 1$m, and he commits an error of $\Delta\ell$. For T he takes the time of n oscillations with the stop watch of least count ΔT and he commits a human error of 0.1 s. For which of the following data, the measurement of g will be most accurate ?

(A) $\Delta L = 0.5, \Delta T = 0.1, n = 20$

(B) $\Delta L = 0.5, \Delta T = 0.1, n = 50$

(C) $\Delta L = 0.5, \Delta T = 0.01, n = 20$

(D) $\Delta L = 0.1, \Delta T = 0.05, n = 50$

Q9. A student performs an experiment to determine the Young's modulus of a wire, exactly 2m long, by Searle's method. In a particular reading, the student measures the extension in the length of the wire to be 0.8 mm with an uncertainty of ± 0.05 mm at a load of exactly 1.0 kg. The student also measures the diameter of the wire to be 0.4 mm with an uncertainty of ± 0.01 mm. Take $g = 9.8$ m/s^2 (exact). The Young's modulus obtained from the reading is –

(A) $(2.0 \pm 0.3) \times 10^{11}$ N/m^2

(B) $(2.0 \pm 0.2) \times 10^{11}$ N/m^2

(C) $(2.0 \pm 0.1) \times 10^{11}$ N/m^2

(D) $(2.0 \pm 0.05) \times 10^{11}$ N/m^2

Q10. A student measured the length of a rod and wrote it as 3.50 cm. which instrument did the use to measure it?

(A) A screw gauge having 100 divisions in the circular scale and pitch as 1 mm.

(B) A screw gauge having 50 divisions in the circular scale and pitch as 1 mm.

(C) A meter scale

(D) A vernier calliper where the 10 divisions in vernier scale matches with 9 divisions in main scale and main scale has 10 divisions in 1 cm.

Q11. Students I, II and III perform an experiment for measuring the acceleration due to gravity (g) using pendulum. They use different lengths of the pendulum and / or record time for different number of oscillations. The observations are shown in the table.

Least count for length = 0.1 cm

Least count for time = 0.1 s

Student	Length of the Pendulum (cm)	Number of oscillations (n)	Total time for (n) oscillations (s)	Time period (s)
I	64.0	8	128.0	16.0
II	64.0	4	64.0	16.0
III	20.0	4	36.0	9.0

If E_I, E_{II} and E_{III} are the percentage error in g, i.e., $\left(\frac{\Delta g}{g}\times 100\right)$ for students I, II and III, respectively.

(A) $E_I = 0$

(B) E_I is minimum

(C) $E_I = E_{II}$

(D) E_{II} is maximum

Q12. A student performs an experiment for determination of $g\left(=\frac{4\pi^2 l}{T^2}\right)$ $l \approx 1$m and he commits an error of Δl. For the experiment takes the time of n oscillations with the stop watch of least count ΔT and he commits a human error of 0.1sec. For which of the following data, the measurement of g will be most accurate?

	Δl	ΔT	n	Amplitude of oscillation
(A)	5 mm	0.2 sec	10	5 mm
(B)	5 mm	0.2 sec	20	5 mm
(C)	5 mm	0.1 sec	20	1 mm
(D)	1 mm	0.1 sec	50	1 mm

Q13. On the basis of detail given about two measuring instruments, select the correct statement.

(i) Vernier callipers having main scale division = 0.05 cm and Vernier scale division $= \frac{2.45}{50}$ cm.

(ii) Screw gaugae having pitch 0.5 mm and its circular scale division measures 0.01 mm.

(A) Both the instruments have same least count.

(B) Least count of screw gauge is lesser than that of vernier callipers.

(C) Both the instruments have same least count but screw gauge is more precise.

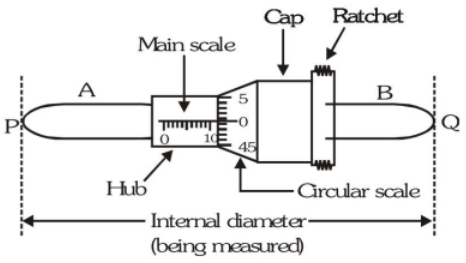
(D) Both the instruments have different least count and screw gauge is more precise.

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 14 to 16

Internal micrometer is a measuring instrument used to measure internal diameter (ID) of a large cylinder bore with high accuracy. Construction is shown in figure. There is one fixed rod B (to the right in figure) and one moving rod A (to the left in figure). It is based on the principle of advancement of a screw when it is rotated in a nut with internal threads. Main scale reading can be directly seen on the hub which is fixed with respect to rod B. When the cap is rotated, rod A moves in or out depending on direction of rotation. The circular scale reading is seen by checking which division of circular scale coincides with the reference line.

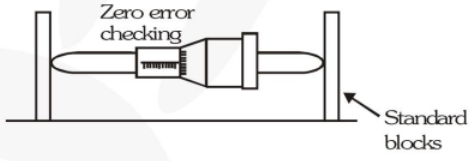


This is to be multiplied by LC to get circular scale reading.

Least count = value of 1 circular scale division

$$= \frac{\text{pitch}}{\text{number of division on circular scale}}$$

Length of rod A is chosen to match the ID (PQ) to be measured. Zero error is checked by taking reading between standard blocks fixed at nominal value of ID to be measured. Zero error is positive if cap end is on the right side of the main scale and negative it is on the left side.



Q14. In an internal micrometer, main scale division is of 0.5 mm and there are 50 divisions in circular scale. The least count of the instrument is -

(A) 0.005 mm

(B) 0.001 mm

(C) 0.05 mm

(D) 0.01 mm

Q15. In the above instrument, while measuring an internal diameter. ID is set of 321 mm with no zero error. If cap end is after 7th division and 17th division of main scale coincides with the reference line, the ID is -

(A) 321. 717 mm

(B) 321.87 mm

(C) 328.17 mm

(D) 324.67 mm

Q16. During zero setting of the above instrument, the end of the cap is on left side of the zero of main scale (i.e. zero of main scale is not visible) and 41st division of circular scale coincides with the reference line, the zero error is -

(A) –0.09 mm (B) +0.41 mm

(C) –0.41 mm (D) +0.09 mm

SUBJECTIVE TYPE

Q17. The time period of oscillation of a simple pendulum is given by $T = 2\pi\sqrt{\ell / g}$. The length of the pendulum is measured as $\ell = 10 \pm 0.1$ cm and the time period as $T = 0.5 \pm 0.02$ s. Determine percentage error in the value of g.

Q18. A body travels uniformly a distance of (13.8 ± 0.2)m in time (4.0 ± 0.3) sec. Calculate its velocity.

Q19. The pitch of a screw gauge is 1 mm and there are 100 divisions on the circular scale. While measuring the diameter of a wire, the linear scale reads 1 mm and 47th division on the circular scale coincides with the reference line. The length of the wire is 5.6 cm. Find the curved surface area (in cm^2) of the wire in appropriate number of significant figures.

Q20. The edge of a cube is measured using a vernier calliper. (9 divisions of the main scale is equal to 10 divisions of vernier scale and 1 main scale division is 1 mm). The main scale division reading is 10 and 1 division of vernier scale was found to be coinciding with the main scale. The mass of the cube is 2.736 g. Calculate the density in g/cm^3 upto correct significant figures.

Q21. 5.74 gm of a substance occupies a volume of 1.2 cm^3. Calculate its density with due regard for significant figures.

Q22. In a Searle's experiment, the diameter of the wire as measured by a screw gauge of least count 0.001 cm is 0.050 cm. The length, measured by a scale of least count 0.1 cm, is 110.0 cm. When a weight of 50N is suspended from the wire, the extension is measured to be 0.125 cm by a micrometer of least count 0.001 cm. Find the maximum error in the measurement of Young's modulus of the material of the wire from these data.

Q23. Two resistance R_1 and R_2 are connected in (i) series and (ii) parallel.

What is the equivalent resistance with limit of possible percentage error in each case of $R_1 = 5.0 \pm 0.2\ \Omega$ and $R_2 = 10.0 \pm 0.1\ \Omega$.

Q24. A glass prism of angle $A = 60°$ gives minimum angle of deviation $\theta = 30°$ with the max. error of 1° when a beam of parallel light passed through the prism during an experiment. Find the permissible error in the measurement of refractive index μ of the material of the prism.

NUMERICAL TYPE

Q25. A physical quantity P is related to four observables A, B, C and D as $P = 4\pi^2A^3B^2 / (\sqrt{C}\ D)$. The percentage error of the measurement in A, B, C and D are 1%, 3% and 2%, 4% respectively. Determine the percentage error & absolute error in the quantity P. Value of P is calculated 3.763.

Q26. A wire of length $\ell = 6 \pm 0.06$ cm and radius $r = 0.5 \pm 0.005$ cm and mass $m = 0.3 \pm 0.003$ gm. Maximum percentage error in density is -

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	A	A	C	A	B	A	A	C	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	B	A	C	C	A	B	C	A	A
21									
B									

Ex-1A

1. B **2.** A,B,C **3.** 0.005 cm **4.** 0.005 mm **5.** 0.882 m^2

6. 3.6×10^5 (2 SF) **7.** (1.6 ± 0.8) cm **8.** 2.84

Ex - 2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	C	C	D	C	A	B	A	A	A
11	**12**	**13**	**14**	**15**	**16**				
C	A	A	A	C	A				

Ex-2A

1. A **2.** D **3.** D **4.** 3 **5.** 1

6. B **7.** A **8.** D **9.** B **10.** 4

11. B **12.** D **13.** A **14.** D **15.** D

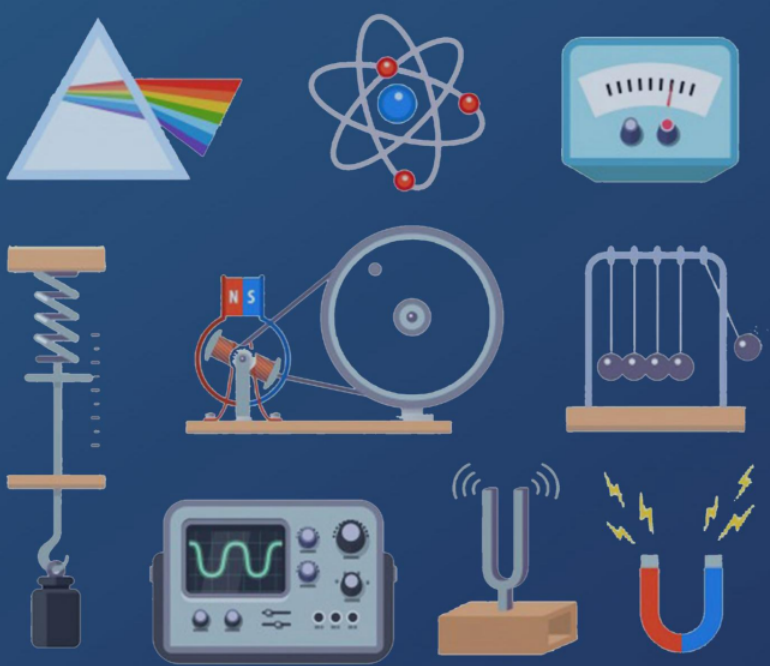
16. A **17.** 9 **18.** $v = (3.45 \pm 0.3)$ m/s **19.** 2.6 cm^2

20. 2.66 g/cm^3 **21.** [4.8 g/cm^3] **22.** 4.89% **23.** [$R_s = 15\Omega \pm 2\%$, $R_p = 3.3\ \Omega \pm 3\%$]

24. $5\pi/18\%$ **25.** 14, 0.526 **26.** 4

PHYSICS

Fluid Mechanics



SHEET

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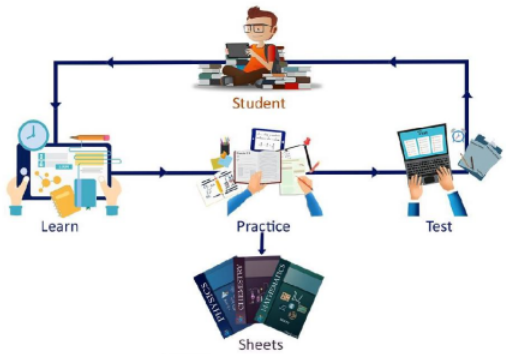
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Pressure				
2	Why is Liquid Surface Horizontal?				
3	Pressure Variation	1-3	1		
4	U-Tube and Barometer	4	11	1	
5	Pascal's Law and Hydrostatic Paradox		2, 12	2-4	1
6	Buoyant Force	5-6	3	5	2
7	Archimedes Principle	7-11	13	6-11	3
8	Eureka-I Found It	12	9	12-14	4
9	Fluid Dynamics	13-14			
10	Bernoulli's Principle	15		15	21
11	Application of Bernoulli's principle	16		16	
12	Speed of Efflux	17	4	17-22	5-9
13	Viscosity	18-19	5, 14	23	10
14	Stokes' Law	20		24	
15	Surface Tension	21-22		25-26	11, 22
16	Excess Pressure in Drops and Bubbles	23	6-7, 10	27	12
17	Contact Angle	24			13
18	Rise of Liquid in Capillary	25		28	14, 23
19	After full chapter		8	29	15-20

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Pressure Variation

Q1. A closed compartment containing gas is moving with some acceleration in horizontal direction. Neglect effect of gravity. Then, the pressure in the compartment is :–

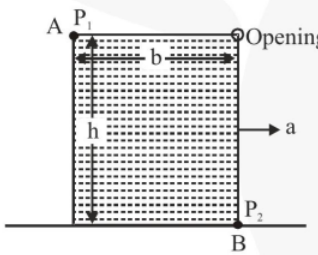
(A) same every where

(B) lower in front side

(C) lower in rear side

(D) lower in upper side

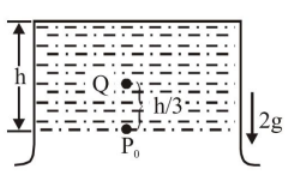
Q2. A closed rectangular vessel completely filled with a liquid of density ρ moves with an acceleration a = g. The value of the pressure difference at point A and B i.e. $(P_1 - P_2)$ is :



(A) ρgb (B) $\frac{\rho g(b+h)}{2}$

(C) ρ(ab – gh) (D) ρgh

Q3. An inverted test tube having a liquid of density ρ accelerates down with a = 2g then, $P_Q - P_0$ is:

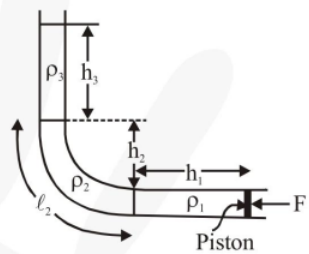


(A) $-\frac{\rho gh}{3}$ (B) $\frac{2\rho gh}{3}$

(C) $\frac{\rho gh}{3}$ (D) indeterminate

U-Tube and Barometer

Q4. A tube is bent into L shape and kept in a vertical plane. If these three liquids are kept in equilibrium by the piston of area A, the value of $\frac{F}{A}$ is :



(A) $(\rho_1 h_1 + \rho_2 h_2 + \rho_3 h_3)g$

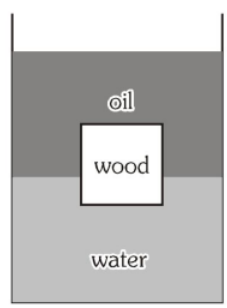
(B) $(\rho_1 h_1 + \rho_2 \ell_2 + \rho_3 h_3)g$

(C) $(\rho_2 h_2 + \rho_3 h_3)g$

(D) $(\rho_2 \ell_2 + \rho_3 h_3)g$

Buoyant Force

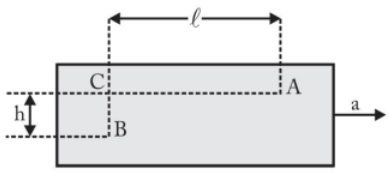
Q5. A cubical block of wood of side of 10 cm, floats at the interface between oil and water as shown in figure with its lower face 2 cm below the interface. The density of oil is 0.6 g/cm^3. The mass of the block is -



(A) 600 g (B) 680 g

(C) 800 g (D) 200 g

Q6. A sealed tank containing a liquid of density ρ moves with a horizontal acceleration a, as shown in the figure. The difference in pressure between the points A and B is -

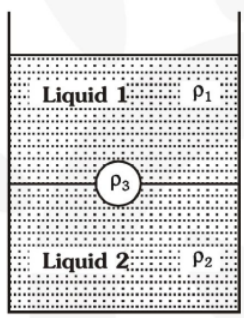


(A) hρg (B) ℓρa
(C) hρg – ℓρa (D) hρg + ℓρa

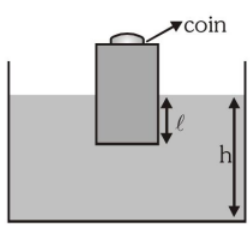
Archimedes Principle

Q7. A jar is filled with two non-mixing liquids 1 and 2 having densities ρ_1 and ρ_2, respectively. A solid ball, made of a material of density ρ_3, is dropped in the jar. It comes to equilibrium in the position shown in the figure. Which of the following is true for ρ_1, ρ_2 & ρ_3.

(A) $\rho_3 < \rho_1 < \rho_2$
(B) $\rho_1 > \rho_3 > \rho_2$
(C) $\rho_1 < \rho_2 < \rho_3$
(D) $\rho_1 < \rho_3 < \rho_2$



Q8. A wooden block, with a coin placed on its top, floats in water as shown in figure. The distance ℓ and h are shown there. After sometime the coin falls into the water. Then:-



(A) ℓ decreases and h increases
(B) ℓ increases and h decreases
(C) both ℓ and h increase
(D) both ℓ and h decrease

Q9. A piece of ice is floating in a jar containing water. When the ice melts, then the level of water :-

(A) Rises
(B) Falls
(C) Remains unchanged
(D) Changes erratically

Q10. A U-tube is partially filled with water. Oil which does not mix with water is next poured into one side, until water rises by 25 cm on the other side. If the density of the oil is 0.8 g/cc, the oil level will stand higher than the water level by :-

(A) 6.25 cm (B) 12.50 cm
(C) 18.75 cm (D) 25.00 cm

Q11. Two solids A and B of equal shape and size float in water. It is observed that A floats with half its volume immersed and B floats with 2/3 of its volume immersed. Compare the densities of A and B-

(A) 4 : 3 (B) 2 : 3
(C) 3 : 4 (D) 1 : 3

Eureka-I Found it

Q12. **Statement–1 :** A solid sphere and a hollow sphere of same material are floating in a liquid. Radius of both the spheres are same. Percentage of volume immersed of both the spheres will be same.

Statement–2 : Upthrust acts on volume of liquid displaced. It has nothing to do whether the body is solid or hollow.

(A) Statement–1 is true, Statement–2 is true; Statement–2 is correct explanation for Statement–1.
(B) Statement–1 is true, Statement–2 is true; Statement–2 is NOT a correct explanation for Statement–1.
(C) Statement–1 is true, Statement–2 is false.
(D) Statement–1 is false, Statement–2 is true.

Fluid Dynamics

Q13. Two water pipes P and Q having diameter 2×10^{-2} m and 4×10^{-2} m respectively are joined in series with the main supply line of water. The velocity of water flowing in pipe P is

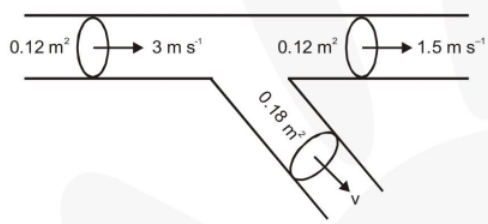
(A) 4 times that of Q

(B) 2 times that of Q

(C) $\frac{1}{2}$ times that of Q

(D) $\frac{1}{4}$ times that of Q

Q14. An incompressible liquid travels as shown in figure. Calculate the speed of the fluid in lower branch.

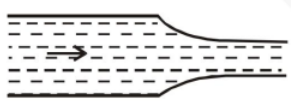


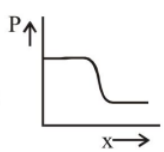
(A) 1 ms^{-1} (B) 2 ms^{-1}

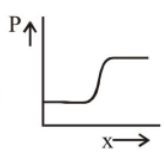
(C) 3 ms^{-1} (D) 4 ms^{-1}

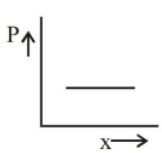
Bernoulli's Principle

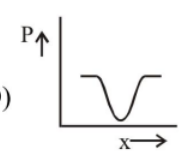
Q15. Water flows through a frictionless duct with a cross-section varying as shown in figure. Pressure P at points along the axis is represented by



(A) 

(B) 

(C) 

(D) 

Application of Bernoulli's Principle

Q16. The cylindrical tube of a spray pump has a radius R, one end of which has n fine holes, each of radius r. If the speed of flow of the liquid in the tube is v, the speed of ejection of the liquid through the hole is :

(A) $\frac{v}{n}\left(\frac{R}{r}\right)$ (B) $\frac{v}{n}\left(\frac{R}{r}\right)^{1/2}$

(C) $\frac{v}{n}\left(\frac{R}{r}\right)^{3/2}$ (D) $\frac{v}{n}\left(\frac{R}{r}\right)^{2}$

Speed of Efflux

Q17. A tank full of water has a small hole at its bottom. Let t_1 be the time taken to empty first one third of the tank and t_2 be the time taken to empty second one third of the tank and t_3 be the time taken to empty rest of the tank then :-

(A) $t_1 = t_2 = t_3$ (B) $t_1 > t_2 > t_3$

(C) $t_1 < t_2 < t_3$ (D) $t_1 > t_2 < t_3$

Viscosity

Q18. Poise is the unit of :-

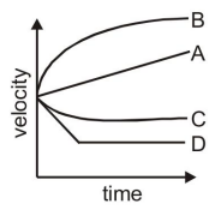
(A) pressure

(B) friction

(C) surface tension

(D) co-efficient of viscosity

Q19. A small ball is left in a viscous liquid from very much height. Correct graph of its velocity with time is :



(A) A (B) B

(C) C (D) D

Stokes' Law

Q20. A small drop of water falls from rest through a large height h in air experiencing viscous force. The final velocity is -

(A) almost independent of h

(B) proportional to $\sqrt{h}$

(C) proportional to h

(D) inversely proportional to h

Surface Tension

Q21. A thin liquid film formed between a U-shaped wire and a light slider supports a weight of 1.5×10^{-2} N (see figure). The length of the slider is 30 cm and its weight negligible. The surface tension of the liquid film is :-

(A) 0.025 Nm^{-1} (B) 0.0125 Nm^{-1}

(C) 0.1 Nm^{-1} (D) 0.05 Nm^{-1}

Q22. A ring of radius r and weight W is lying on a liquid surface. If the surface tension of the liquid is T, then the minimum force required to be applied in order to lift the ring up -

(A) W (B) 2W

(C) $W + 4\pi rT$ (D) $W + 2\pi rT$

Excess Pressure in Drops and Bubbles

Q23. A water drop is divided into 8 equal droplets. The pressure difference between inner and outer sides of the big drop :-

(A) will be the same as for smaller droplet

(B) will be half of that for smaller droplet

(C) will be one-forth of that for smaller droplet

(D) will be twice of that for smaller droplet

Contact Angle

Q24. Shape of meniscus for a liquid of zero angle of contact is :-

(A) plane

(B) parabolic

(C) hemi-spherical

(D) cylindrical

Rise of Liquid in capillary

Q25. In a surface tension experiment with a capillary tube water rises up to 0.1 m. If the same experiment is repeated on an artificial satellite which is revolving round the earth, water will rise in the capillary tube up to a height of :-

(A) 0.1 m

(B) 0.98 m

(C) 9.8 m

(D) full length of capillary tube

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A beaker is filled in with water is accelerated a m/s^2 in + x direction. The surface of water shall make an angle :

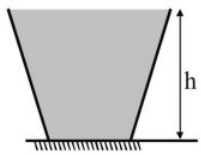
(A) $\tan^{-1}(a/g)$ backwards

(B) $\tan^{-1}(a/g)$ forwards

(C) $\cot^{-1}(g/a)$ backwards

(D) $\cot^{-1}(g/a)$ forwards

Q2. M gm of a liquid of density ρ is filled in a light beaker and kept on a horizontal table as shown in the figure. The height of the liquid in the beaker is h. The beaker is wider on top than at its base and the cross-sectional area of the base is A. Neglect the effect of atmospheric pressure. Now, choose the **CORRECT** statement(s) from the following.



(A) The pressure of liquid at the bottom surface is ρgh.

(B) The normal reaction exerted by the table on the beaker is ρghA.

(C) The pressure of the liquid at the bottom surface is $\frac{Mg}{A}$.

(D) The normal reaction exerted by the table on the beaker is Mg.

Q3. A cubical block is floating in a liquid with one third of its volume immersed in the liquid. When the whole system accelerates upwards with acceleration of g/2 :-

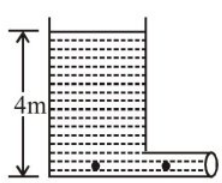
(A) the fraction of volume immersed in the liquid will change.

(B) the buoyancy force on the block will change.

(C) the buoyancy force will increase by 50 percent.

(D) the pressure in the liquid will increased.

Q4. A vent tank of large cross-sectional area has a horizontal pipe 0.12 m in diameter at the bottom. This holds a liquid whose density is 1500 kg/m^3 to a height of 4.0 m. Assume the liquid is an ideal fluid in laminar flow. In figure, the velocity with which fluid flows out is **:-**



(A) $2\sqrt{5}$ m/s

(B) $\sqrt{5}$ m/s

(C) $4\sqrt{5}$ m/s

(D) $\sqrt{10}$ m/s

Q5. A Newtonian fluid fills the clearance between a shaft and a sleeve. When a force of 800N is applied to the shaft, parallel to the sleeve, the shaft attains a speed of 1.5 cm/sec. If a force of 2.4 kN is applied instead, the shaft would move with a speed of :-

(A) 1.5 cm/sec (B) 13.5 cm/sec

(C) 4.5 cm/sec (D) None

Q6. If two soap bubbles of different radii are connected by a tube,

(A) air flows from the bigger bubble to the smaller bubble till the sizes become equal

(B) air flows from bigger bubble to the smaller bubble till the sizes are interchanged

(C) air flows from the smaller bubble to the bigger

(D) there is no flow of air.

Q7. When an air bubble rises from the bottom of a deep lake to a point just below the water surface, the pressure of air inside the bubble:

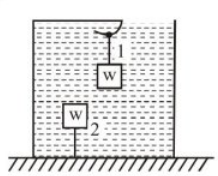
(A) is greater than the pressure outside it

(B) is less than the pressure outside it

(C) increases as the bubble moves up

(D) remains same as the bubble moves up

Q8. An iron block and a wooden block are positioned in a vessel containing water as shown in the figure. The iron block (1) hangs from a massless string with a rigid support from the top while the wooden block (2) floats being tied to the bottom through a massless string. If now the vessel starts acceleration towards right.



(A) iron block gets deflected towards right.

(B) wooden block gets deflected towards right.

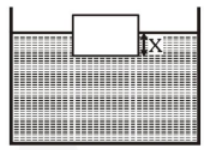
(C) iron block gets deflected towards left.

(D) wooden block gets deflected towards left.

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q9. A cube is floating in a liquid as shown in figure.



Column-I	Column-II
(A) If density of liquid decreases then x will	(P) increase
(B) If size of cube is increased then x will	(Q) decrease
(C) If the whole system is accelerated upwards then x will	(R) remains same

Q10. Two soap bubbles coalesce to form a single large bubble :

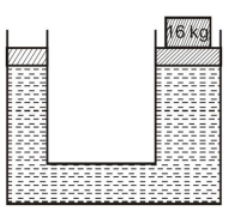
Column-I	Column-II
(A) Surface energy in the process will	(P) increase
(B) Temperature of the bubble will	(Q) decrease
(C) Pressure inside the soap bubble will	(R) remains same

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q11. A mercury barometer reads 75 cm in a stationary lift. What reading does it show when the lift is moving downwards, with an acceleration of 1 m/s^2 ?

Q12. The area of cross-section of wider tube is 800 cm^2. If a mass of 16 kg is placed on the massless piston, find the difference in the level of water in the two tubes.



SUBJECTIVE TYPE

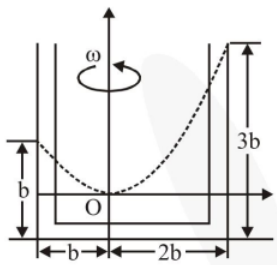
Q13. A certain block weighs 15N in air, it weighs 12N when immersed in water. When immersed in another liquid, it weighs 13N, calculate the relative density of (i) the block (ii) the other liquid.

Q14. A large wooden plate of area $10m^2$ floating on the surface of a river is made to move horizontally with a speed of 2 m/s by applying a tangential force. If the river is 1 m deep and the water in contact with the bed is stationary, find the tangential force needed to keep the plate moving. Coefficient of viscosity of water at the temperature of the river = 10^{-2} poise.

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

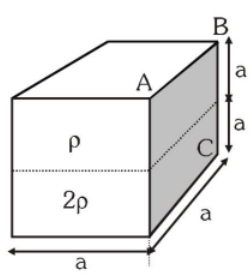
Q1. A vertical U-shaped tube having a liquid rotates about the vertical axis. The value of ω is :



(A) $\sqrt{\frac{g}{b}}$ (B) $2\sqrt{\frac{g}{3b}}$

(C) $\sqrt{\frac{g}{2b}}$ (D) none of these

Q2. A cuboid (a × a × 2a) is filled with two immiscible liquids of density 2ρ & ρ as shown in the figure. Neglecting atmospheric pressure, ratio of force on base & side wall of the cuboid is :-



(A) 2 : 3 (B) 1 : 3

(C) 5 : 6 (D) 6 : 5

Q3. What is the pressure 200 m below the surface of the ocean if the sp. gravity of sea water is 1.03

[Atmospheric pressure = 1.013×10^5 N/m^2].

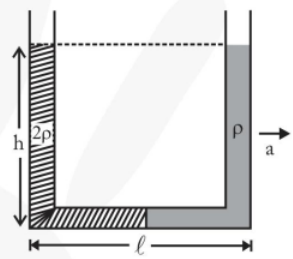
(A) 21.2×10^5 N/m^2

(B) 20.4×10^5 N/m^2

(C) 40.0×10^4 N/m^2

(D) 21.2×10^6 N/m^2

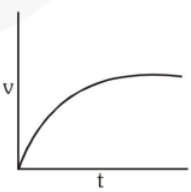
Q4. A U–tube of base length 'ℓ' filled with same volume of two liquids of densities ρ and 2ρ is moving with an acceleration 'a' on the horizontal plane. If the height difference between the two surfaces (open to atmosphere) becomes zero, then the height h is given by -

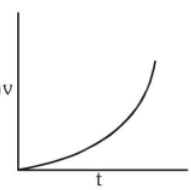


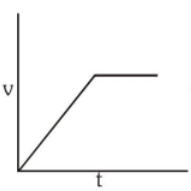
(A) $\frac{a}{2g}\ell$ (B) $\frac{3a}{2g}\ell$

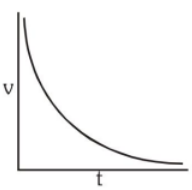
(C) $\frac{a}{g}\ell$ (D) $\frac{2a}{3g}\ell$

Q5. A piece of cork starts from rest at the bottom of a lake and floats up. Its velocity v is plotted against time t. Which of the following best represents the resulting curve-

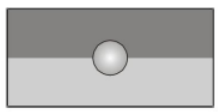
(A) 

(B) 

(C) 

(D) 

Q6. A solid uniform ball having volume V and density ρ floats at the interface of two immiscible liquids as shown in figure. The densities of the upper and the lower liquids are ρ_1 and ρ_2 respectively, such that $\rho_1 < \rho < \rho_2$. What fraction of the volume of the ball will be in the lower liquid :-



(A) $\frac{\rho-\rho_2}{\rho_1-\rho_2}$ (B) $\frac{\rho_1}{\rho_1-\rho_2}$

(C) $\frac{\rho_1-\rho}{\rho_1-\rho_2}$ (D) $\frac{\rho_1-\rho_2}{\rho_2}$

Q7. A wooden ball of density D is immersed in water of density d to a depth h below the surface of water. Upto which height the ball will jump out of water, when it is released ?

(A) $\frac{d}{D}h$ (B) $\left(\frac{d}{D}-1\right)h$

(C) h (D) Zero

Q8. A steel ball is floating in a trough of mercury. If we fill the empty part of the trough with water, what will happen to the steel ball :-

(A) It will continue in its position

(B) It will move up

(C) It will move down

(D) It will execute vertical oscillations

Q9. A wooden block floats in water in a sealed container. When the container is at rest, 25% of the block is above the water. Consider the following five situation :

(i) the container is lifted up at constant speed.

(ii) the container is lowered at constant speed.

(iii) the container is lifted up at an increasing speed.

(iv) the container is lowered at a decreasing speed.

(v) the air pressure above the water in the container is increased.

What happens in each situation?

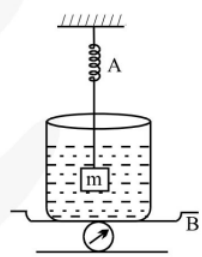
(A) 75% of block is submerged in siutation (i) & (ii) and higher fraction is submerged in situations (iii), (iv) & (v).

(B) 75% of block is submerged in situation (i), (ii) & (v) and higher fraction is submerged in situations (iii), (iv).

(C) 75% of block is submerged in situation (i), (ii), (iii) & (iv) and higher fraction is submerged in situations (v).

(D) 75% of block is submerged in all situation.

Q10. The spring balance A reads 2 kg with a block m suspended from it. A balance B reads 5 kg when a beaker with liquid is put on the pan of the balance. The two balances are now so arranged that the hanging mass is inside the liquid in the beaker as shown in the figure in this situation :



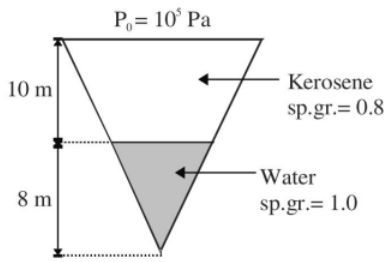
(A) the balance A will read more than 2 kg

(B) the balance B will read more than 5 kg

(C) the balance A will read less than 2 kg and B will read less than 5 kg

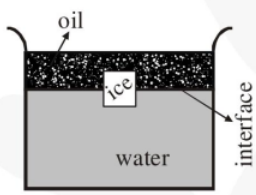
(D) the balances A and B will read 2 kg and 5 kg respectively.

Q11. Shown in figure, a conical container of half-apex angle 37° filled with certain quantities of kerosene and water. The force exerted by the water on the kerosene is approximately, (Take atmospheric pressure = 10^5 Pa).



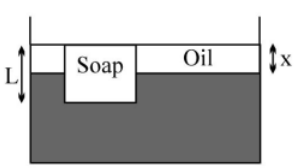
(A) 3×10^7 N (B) 4×10^7 N
(C) 2×10^7 N (D) 5×10^7 N

Q12. An ice cube is floating in water above which a layer of a lighter oil is poured. As the ice melts completely, the level of interface and the upper most level of oil will respectively:-



(A) rise and fall
(B) fall and rise
(C) rise and not change
(D) not change and fall

Q13. A rectangular bar of soap has density 800 kg/m³ floats in water of density 1000 kg/m³. Oil of density 300 kg/m³ is slowly added, forming a layer that does not mix with the water. When the top surface of the oil is at the same level as the top surface of the soap. What is the ratio of the oil layer thickness to the soap's thickness, x/L ?



(A) $\frac{2}{10}$ (B) $\frac{2}{7}$ (C) $\frac{3}{10}$ (D) $\frac{3}{8}$

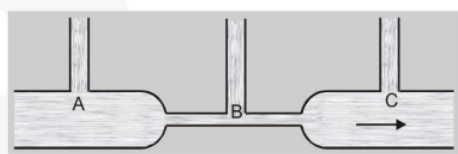
Q14. The total weight of a piece of wood is 6 kg. In the floating state in water its $\frac{1}{3}$ part remains inside the water. On this floating solid, what maximum weight is to be put such that the whole of the piece of wood is to be drowned in the water :-

(A) 12 kg (B) 10 kg
(C) 14 kg (D) 15 kg

Q15. Water is flowing steadily through a horizontal tube of non uniform cross-section. If the pressure of water is 4×10^4 N/m² at a point where cross-section is 0.02 m² and velocity of flow is 2 m/s, what is pressure at a point where cross-section reduces to 0.01 m².

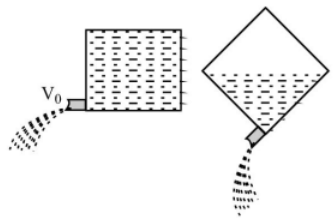
(A) 1.4×10^4 N/m² (B) 3.4×10^4 N/m²
(C) 2.4×10^{-4} N/m² (D) none of these

Q16. In the figure below is shown the flow of liquid through a horizontal pipe. Three tubes A, B and C are connected to the pipe. The radii of the tubes, A, B and C at the junction are respectively 2 cm, 1 cm. and 2 cm. It can be said that the :-



(A) height of the liquid in the tube A is maximum
(B) height of the liquid in the tubes A and B is the same
(C) height of the liquid in all the three tubes is the same
(D) height of the liquid in the tubes A and C is the same

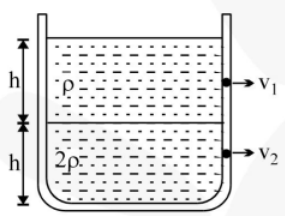
Q17. A cubical box of wine has a small spout located in one of the bottom corners. When the box is full and placed on a level surface, opening the spout results in a flow of wine with a initial speed of v_0 (see figure). When the box is half empty, someone tilts it at 45° so that the spout is at the lowest point (see figure). When the spout is opened the wine will flow out with a speed of :



(A) v_0 (B) $v_0/2$

(C) $v_0/\sqrt{2}$ (D) $v_0/\sqrt[4]{2}$

Q18. Equal volumes of two immiscible liquids of densities ρ and 2ρ are filled in a vessel as shown in figure. Two small holes are punched at depth h/2 and 3h/2 from the surface of lighter liquid. If v_1 and v_2 are the velocities of a efflux at these two holes, then v_1/v_2 is :



(A) $\frac{1}{2\sqrt{2}}$ (B) $\frac{1}{2}$

(C) $\frac{1}{4}$ (D) $\frac{1}{\sqrt{2}}$

Q19. Water from a tap emerges vertically downwards with an initial speed of 1.0 m/s. The cross–sectional area of tap is 10^{-4} m^2. Assume that the pressure is constant throughout the stream of water and that the flow is steady, the cross–sectional area of stream 0.15 m below the tap is :–

(A) 5.0×10^{-4} m^2

(B) $1.0 \times \times 10^{-4}$ m^2

(C) $5.0 \times \times 10^{-5}$ m^2

(D) $2.0 \times \times 10^{-5}$ m^2

Q20. A large open tank has two holes in the wall. One is a square hole of side L at a depth y from the top and the other is a circular hole of radius R at a depth 4y from the top. When the tank is completely filled with water, the quantities of water flowing out per second from the holes are both same. Then, R is equal to :-

(A) $\frac{L}{\sqrt{2\pi}}$ (B) $2\pi L$ (C) L (D) $\frac{L}{2\pi}$

Q21. A cylindrical vessel is filled with water up to height H.A hole is bored in the wall at a depth h from the free surface of water. For maximum range, h is equal to :-

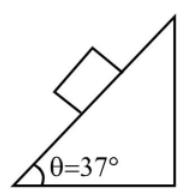
(A) $\frac{H}{4}$ (B) $\frac{H}{2}$ (C) $\frac{3H}{4}$ (D) H

Q22. A cylindrical vessel of cross-sectional area 1000 cm^2 is fitted with a frictionless piston of mass 10 kg and filled with water completely. A small hole of cross-sectional area 10 mm^2 is opened at a point 50 cm deep from the lower surface of the piston. The velocity of efflux from the hole will be :-

(A) 10.5 m/s (B) 3.4 m/s

(C) 0.8 m/s (D) 0.2 m/s

Q23. A cubical block of side 'a' and density 'ρ' slides over a fixed inclined plane with constant velocity 'v'. There is a thin film of viscous fluid of thickness 't' between the plane and the block. Then the coefficient of viscosity of the thin film will be:



(A) $\frac{3\rho a g t}{5v}$ (B) $\frac{4\rho a g t}{5v}$

(C) $\frac{\rho a g t}{v}$ (D) none of these

Q24. If a ball of steel (density $\rho = 7.8$ g cm^{-3}) attains a terminal velocity of 10 cm s^{-1} when falling in a tank of water (coefficient of viscosity $\eta_{water} = 8.5 \times 10^{-4}$ Pa–s) then its terminal velocity in glycerine ($\sigma = 1.2$ g cm^{-3}, $\eta_{gly} = 13.2$ Pa–s) would be nearly :-

(A) 1.6×10^{-5} cm s^{-1}

(B) 3.98×10^{-4} cm s^{-1}

(C) 6.25×10^{-4} cm s^{-1}

(D) 1.5×10^{-5} cm s^{-1}

Q25. Two merucry drops (each of radius 'r') merge to form a bigger drop. The surface energy of the bigger drop, if $\frac{1}{\pi}$ is the surface tension (in SI unit), is :

(A) $2^{5/3} r^2$ (B) $4r^2$

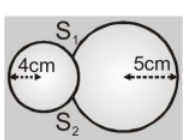
(C) $2r^2$ (D) $2^{8/3} r^2$

Q26. Two drops of same radius are falling through air with steady velocity of v cm/s. If the two drops collapse, what would be the terminal velocity ?

(A) 4 v (B) $(4)^{1/3}$ v

(C) 2 v (D) 64 v

Q27. Two soap bubbles of radii r_1 and r_2 equal to 4cm and 5 cm are touching each other over a common surface S_1S_2 (shown in figure). Its radius will be :-



(A) 4 cm (B) 20 cm

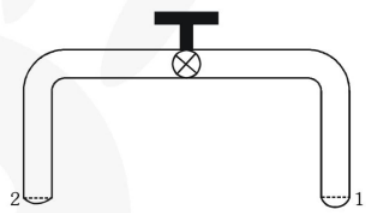
(C) 5 cm (D) 4.5 cm

Q28. If a capillary of radius r is dipped in water, the height of water that rises in it is h and its mass is M. If the radius of the capillary is doubled the mass of water that rises in the capillary will be

(A) 4M (B) 2M

(C) M (D) $\frac{M}{2}$

Q29. A glass tube of uniform internal radius (r) has a valve separating the two identical ends. Initially, the valve is in a tightly closed position. End 1 has a hemispherical soap bubble of radius r. End 2 has sub–hemispherical soap bubble as shown in figure. Just after opening the valve,



(A) Air from end 1 flows towards end 2. No change in the volume of the soap bubbles.

(B) Air from end 1 flows towards end 2. Volume of the soap bubble at end 1 decreases.

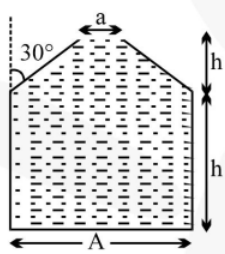
(C) No change occurs

(D) Air from end 2 flows towards end 1. Volume of the soap bubble at end 1 increases.

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The vessel shown in the figure has two sections. The lower part is a rectangular vessel with area of cross-section A and height h. The upper part is a conical vessel of height h with base area 'A' and top area 'a' and the walls of the vessel are inclined at an angle 30° with the vertical. A liquid of density ρ fills both the sections upto a height 2h. Neglecting atmospheric pressure.



(A) The force F exerted by the liquid on the base of the vessel is $2h\rho g\,\frac{(A+a)}{2}$

(B) the pressure P at the base of the vessel is $2h\rho g\,\frac{A}{a}$

(C) the weight of the liquid W is greater than the force exerted by the liquid on the base

(D) the walls of the vessel exert a downward force on the liquid.

Q2. A heavy hollow cone of radius R and height h is placed on a horizontal table surface, with its flat base on the table. The whole volume inside the cone is filled with water of density ρ. The circular rim of the cone's base has a watertight seal with the table's surface and the top apex of the cone has a small hole. Neglecting atmospheric pressure, find the total upward force exerted by water on the cone is -

(A) $(2/3)\pi R^2h\rho g$ (B) $(1/3)\pi R^2h\rho g$

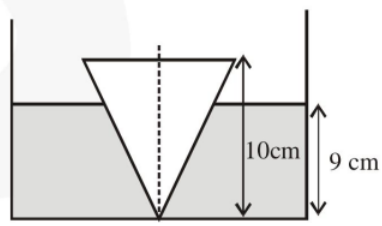
(C) $\pi R^2h\rho g$ (D) None

Q3. A solid floats with 2/3 of its volume immersed in a liquid and with 3/4 of its volume immersed in another liquid. What fraction of its volume will be immersed if it floats in a homogenous mixture formed of equal volumes of the liquids?

(A) 6/7 (B) 8/11

(C) 11/16 (D) 12/17

Q4. An inverted ice cone of height 10 cm is immersed in water as shown below. Tip of cone is touching the base of vessel filled with water upto a height of 9 cm. (Specific Gravity of ice is 0.9)



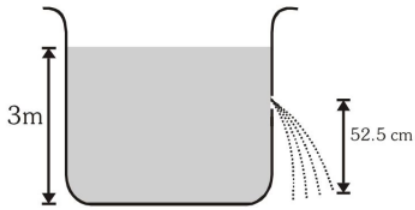
(A) Normal contact force between cone & vessel is zero.

(B) After melting of ice, the level of water will increase.

(C) Potential energy of ice–liquid system will decrease after melting of ice.

(D) Cone is in stable equilibrium.

Q5. Water is filled in a cylindrical container to a height of 3 m. The ratio of the cross–sectional area of the orifice and the beaker is 0.1. The square of the speed of the liquid coming out from the orifice is ($g = 10\ m/s^2$)

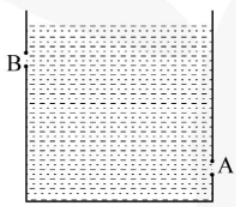


(A) 50 m^2s^2 (B) 50.5 m^2s^2
(C) 51 m^2s^2 (D) 52 m^2s^2

Q6. A small ball of relative density 0.8 falls into water from a height of 2m. The depth to which the ball will sink is (neglect viscous forces) :

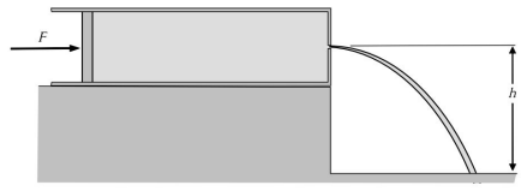
(A) 8 m (B) 2 m
(C) 6 m (D) 4 m

Q7. Two identical holes each of cross-sectional area 10^{-3} m^2 are made on the opposite sides of a tank containing water as shown in the figure. As the water comes out of the holes, the tank will experience a net horizontal force of 20 N. The difference in height between the holes A and B is -



(A) 1 m (B) 0.5 m
(C) 2 m (D) 0.25 m

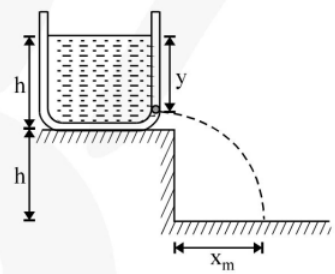
Q8. An ideal liquid of density ρ is filled in a horizontally fixed syringe fitted with piston. There is no friction between the piston and the inner surface of the syringe. Cross-section area of the syringe is A. At one end of the syringe, an orifice of negligible cross-section area is made. When the piston is pushed into the syringe, the liquid comes out of the orifice following parabolic path and falls on the ground. With what speed the liquid strikes the ground? Neglect the air drag :-



(A) $\sqrt{\frac{F+\rho ghA}{\rho A}}$ (B) $\sqrt{\frac{F+2\rho ghA}{\rho A}}$

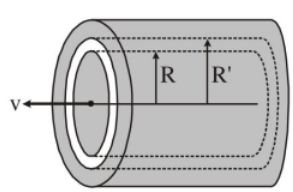
(C) $\sqrt{\frac{2F+\rho ghA}{\rho A}}$ (D) $\sqrt{\frac{2(F+\rho ghA)}{\rho A}}$

Q9. A tank is filled upto a height h with a liquid and is placed on a platform of height h from the ground. To get maximum range x_m a small hole is punched at a distance of y from the free surface of the liquid. Then -



(A) $x_m = 2h$ (B) $x_m = 1.5\ h$
(C) $y = h$ (D) $y = 0.75\ h$

Q10. Figure shows a long solid cylinder of radius R inside a long hollow tube of inner radius R′. A viscous liquid of coefficient of viscosity η is filled in the gap between the cylinder and the hollow tube. If the solid cylinder is moved with velocity v parallel to its length inside the fixed hollow tube, find the force required per unit length to be applied on the solid cylinder, assuming uniform velocity gradient in the liquid.



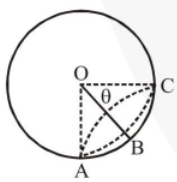
(A) $\eta(2\pi R')\left(\frac{V}{R'-R}\right)$

(B) $\eta(2\pi R)\left(\frac{V}{R'-R}\right)$

(C) $\eta(4\pi R')\left(\frac{V}{R'+R}\right)$

(D) $\eta(4\pi R)\left(\frac{V}{R'+R}\right)$

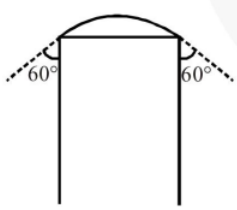
Q11. Consider a small water drop in air. If T is the surface tension, then what is the force due to surface tension acting on the smaller section ABC ?



(A) $2TR\pi$ (B) $2\pi TR\sin\theta$

(C) $2\pi TR\sin^2\theta$ (D) $2\pi TR\sin^3\theta$

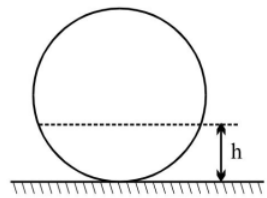
Q12. A soap bubble is being blown on a tube of radius 1 cm. The surface tension of the soap solution is 0.05 N/m and the bubble makes an angle of 60° with the tube as shown. The excess of pressure over the atmospheric pressure in the tube is :



(A) 5 Pa (B) 1 Pa

(C) 10 Pa (D) 20 Pa

Q13. A liquid is filled in a spherical container of radius R till a height h. At this position the liquid surface at the edges is also horizontal. The contact angle is :-



(A) 0 (B) $\cos^{-1}\left(\frac{R-h}{R}\right)$

(C) $\cos^{-1}\left(\frac{h-R}{R}\right)$ (D) $\sin^{-1}\left(\frac{R-h}{R}\right)$

Q14. When a capillary tube is dipped in a liquid, the liquid rises to a height h in the tube. The free liquid surface inside the tube is hemispherical in shape. The tube is now pushed down so that the height of the tube outside the liquid is less than h :-

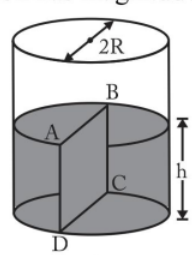
(A) The liquid will come out of the tube like in a small fountain.

(B) The liquid will ooze out of the tube slowly.

(C) The liquid will fill the tube but not come out of its upper end.

(D) The free liquid surface inside the tube will not be hemispherical.

Q15. Water is filled up to a height h in a beaker of radius R as shown in the figure. The density of water is r, the surface tension of water is T and the atmospheric pressure is P_0. Consider a vertical section ABCD of the water column through a diameter of the beaker. The force on water on one side of this section by water on the other side of this section has magnitude :–



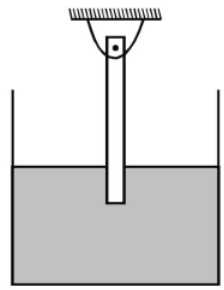
(A) $[2P_0Rh + \pi R^2\rho gh - 2RT]$

(B) $[2P_0Rh + R\rho gh^2 - 2RT]$

(C) $[P_0\pi R^2 + R\rho gh^2 - 2RT]$

(D) $[P_0\pi R^2 + R\rho gh^2 + 2RT]$

Q16. A thin vertical uniform wooden rod is pivoted at the top and immersed in water as shown. The container is slowly raised. At a certain moment, the equilibrium becomes unstable. If density of water is 9/5 times the density of wood, then ratio of total length of rod to the submerged length of rod, at that moment is



(A) 2 (B) 3 (C) 4 (D) 6

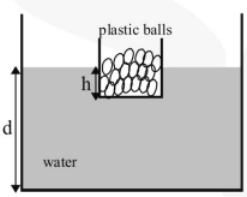
MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q17. Column I shows different system as describe, with some parameter while column-II gives the change in the parameter.

Column-I **Column-II**

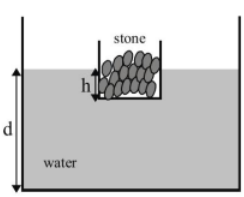
(A)



(P) h decreases

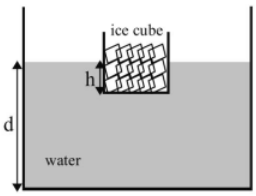
Plastic ball is thrown from the container in the water.
[d is the height of water level while h is the depth to which the container is submerged]

(B)



(Q) h remain same

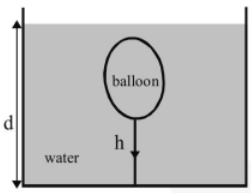
Stone is thrown from the container in the water.
[d is the height of water level while h is the depth to which the container is submerged]

(C) 

(R) h increases

Ice melts and remain in the container.

[d is the height of water level while h is the depth to which the container is submerged]

(D) 

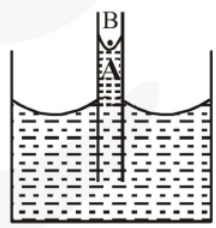
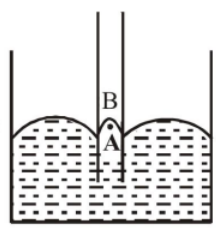
(S) d decreases

The water is heated slowly.

[d is the height of water level while h is the tension in the string. $\gamma_{air} > \gamma_{water}$]

(T) d remain same

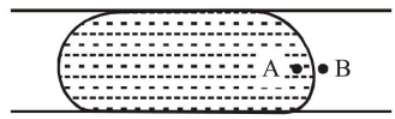
Q18. Capillary rise and shape of droplets on a plate due to surface tension are shown in column-II. Point A and B are just inside and outside the surface. Match the following

Column-I	**Column-II**
(A) Liquid is wetting the solid	(P) 
(B) Liquid is not wetting the solid	(Q) 

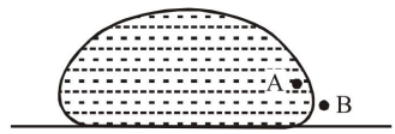
(C) Pressure at A > pressure at B

(D) Pressure at B > Pressure at A

(R) A liquid drop is pressed between two parallel glass plates.



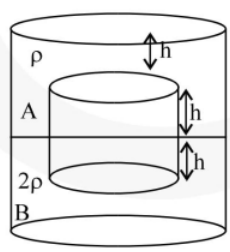
(S)



(T)

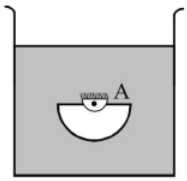
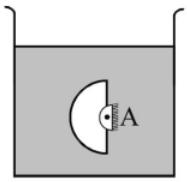
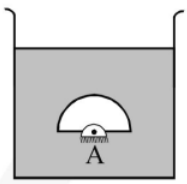
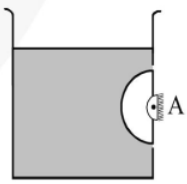
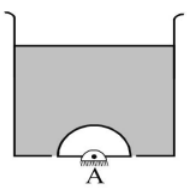
both end open cylindrical pipe

Q19. Shown below is a cylinder of radius R floating in vessel containing liquids A and B. Neglecting atmospheric pressure match the quantities mentioned in column-I with corresponding expression in column-II.



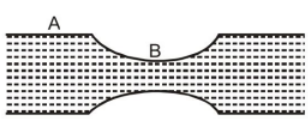
Column-I	**Column-II**
(A) Net force exerted by liquid A of density ρ on the cylinder.	(P) $9\ \rho g R h^2$
(B) Net force exerted by liquid B of density 2ρ on the cylinder.	(Q) $\pi\rho g R^2 h$
(C) Net force exerted by liquids A and B on the left half of the curved part of cylinder.	(R) $4\pi\rho g R^2 h$
(D) Net force exerted by liquid A and B on the cylinder.	(S) $3\pi\rho g R^2 h$

Q20. In column-II semi-cylinder of material having density less than fluid is hinged about point A

Column-I	**Column-II**
(A) Torque is clockwise.	(P) 
(B) Effective force due to fluid is at COM of body	(Q) 
(C) Body in stable equilibrium.	(R) 
(D) Force due to fluid produces no torque about axis.	(S) 
	(T) 

SUBJECTIVE TYPE

Q21. Water flows in a horizontal tube as shown in figure. The pressure of water changes by 600 N/m^2 between A and B where the area of cross-section are 30 cm^2 and 15 cm^2 respectively. Find the rate of flow of water through the tube.



Q22. A liquid drop of radius 'r' is divided into 64 similar tiny droplets. If the surface tension of liquid is T. Calculate the increase in surface energy ?

Q23. On dipping one end of a capillary in liquid and inclining the capillary at an angles 30° and 60° with the vertical, the lengths of liquid columns in it are found to be ℓ_1 and ℓ_2 respectively. Find the ratio of ℓ_1 and ℓ_2 ?

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	C	C	C	B	D	D	D	C	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	D	A	A	A	D	C	D	C	A
21	**22**	**23**	**24**	**25**					
A	C	B	C	D					

Ex-1A

1. A,C **2.** A,D **3.** B, C, D **4.** C **5.** C

6. C **7.** A **8.** B, C **9.** (A) P, (B) P, (C) R

10. (A) Q, (B) P, (C) Q **11.** 83.33 cm **12.** 20 cm **13.** 5, 0.67

14. 2×10^{-2} N

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	**D**	**A**	**B**	**A**	**C**	**B**	**B**	**D**	**B**
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	**A**	**B**	**A**	**B**	**D**	**D**	**D**	**C**	**A**
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	
B	**B**	**A**	**C**	**D**	**B**	**B**	**B**	**B**	

Ex-2A

1. D **2.** A **3.** D **4.** B,C **5.** A

6. A **7.** A **8.** D **9.** A,C **10.** B

11. C **12.** C **13.** B **14.** C,D **15.** B

16. B

17. (A)-P,T; (B)-P,S; (C)-Q,T; (D)-R

18. (A)-P,T; (B)-Q,R,S; (C)-Q,R,S,T; (D)-P

19. (A)-Q, (B)-R, (C)-P, (D)-S

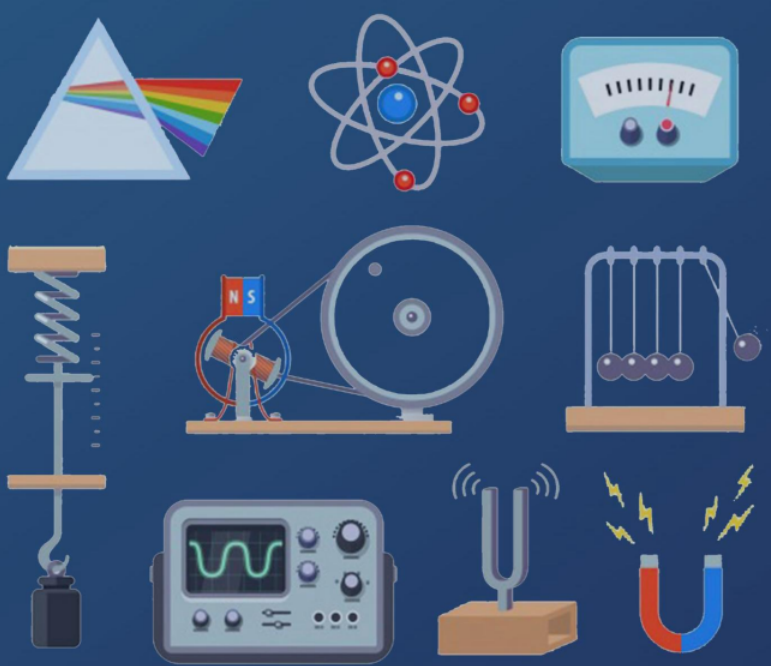
20. (A) $\rightarrow$(Q); (B) $\rightarrow$(PQR); (C) $\rightarrow$(R); (D) $\rightarrow$(PRST)

21. $\frac{6}{\sqrt{10}} \times 10^{-3}\,m^3/s$ **22.** $12\pi r^2 T$ **23.** $\frac{1}{\sqrt{3}}$

-: Important Notes & Formulas :-

PHYSICS

Friction



SHEET

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Contents

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4.	Exercise 1A	Page - 5
5.	Exercise 2	Page - 8
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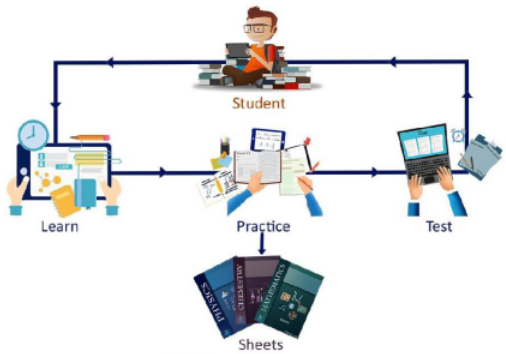
7.	Answer Key	Page - 13

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr. No.	Topic	Ex - 1	Ex - 1A	Ex - 2	Ex - 2A
1	Static and Kinetic Friction	1-5	1		
2	Basic Problems in Friction	6-8	2	1	
3	A Systematic Approach to Friction	9,10	3,5-8	2-4	1,2
4	Two Block Problems	11-14		5,6	3,6-10
5	Angle of Repose	15,16	9.10	7,8	
6	Net Contact Force	17	4		4
7	Miscellaneous Problems			9	5

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Static and Kinetic Friction

Q1. The coefficient of static friction between two surface depend on-

(A) Nature of surface

(B) The shape of the surface in contact

(C) The area of contact

(D) All of the above

Q2. Maximum value of static friction is known as :-

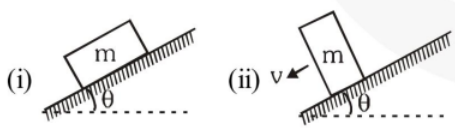
(A) Limiting friction

(B) Kinetic friction

(C) Normal reaction

(D) Coefficient of friction

Q3. A block is first placed on its long side and then on its short side on the same inclined plane, as shown. The block slides down the plane on its short side but remains at rest on its long side. A possible explanation is:



(A) the short side is smoother than long side

(B) the frictional force is less because the contact area is less

(C) the center of gravity is higher in the second case

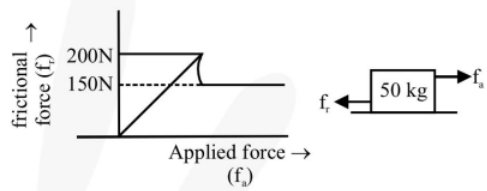
(D) the normal force is less in the second case

Q4. A 20 kg block is resting on a horizontal floor. A force of 75 N is required to just move the block and a force of 60 N is required to move the block with constant velocity then coefficient of static friction is :-

(A) 0.375 (B) 0.44

(C) 0.52 (D) 0.60

Q5. The graph between applied force and frictional force for a body of mass 50 kg placed on a horizontal surface is as shown in figure the value of cofficient of static and kinetic friction will be :

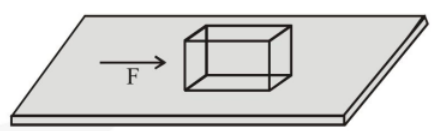


(A) 0.4, 0.3 (B) 0.3, 0.2

(C) 0.4, 0.2 (D) 0.2, 0.3

Basic Problems in Friction

Q6. A 2 kg block is resting on horizontal surface. If coefficient of static friction is 0.4 and 2.5 N force is applied on the block then the friction on the block is :-



(A) 2.5 N (B) 5 N

(C) 7.84 N (D) 10 N

Q7. A block is mass 'm' is resting on the floor of a lift which is moving downward with acceleration of 'g'. If the block is pulled along the surface and coefficient of friction is μ then the friction on block is :-

(A) mg (B) μmg

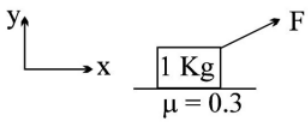
(C) 2 μmg (D) Zero

Q8. A marble block of mass 2 kg lying on ice when given a velocity of 6 m/s is stopped by friction in 10s. Then the coefficient of friction is-

(A) 0.02 (B) 0.03 (C) 0.06 (D) 0.01

A Systematic Approach to Friction

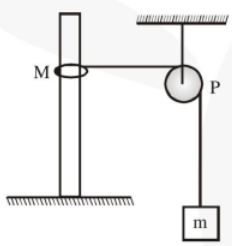
Q9. A force $\vec{F} = \hat{i} + 4\hat{j}$ acts on block shown. The force of friction acting on the block is :



(A) $-\hat{i}$ (B) $-1.8\hat{i}$

(C) $-2.4\hat{i}$ (D) $-3\hat{i}$

Q10. In the figure shown a ring of mass M and a block of mass m are in equilibrium. The string is light and pulley P does not offer any friction and coefficient of friction between pole and M is μ. The frictional force offered by the pole on M is :



(A) Mg directed up

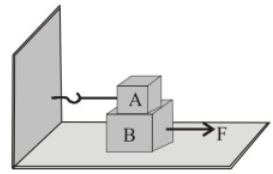
(B) μmg directed up

(C) $(M - m)$g directed down

(D) μmg directed down

Two Block Problems

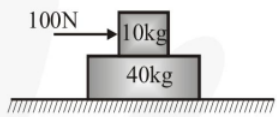
Q11. A block A with mass 100 kg is resting on another block B of mass 200 kg. As shown in fugure a horizontal rope tied to a wall holds it. The coefficient of friction between A and B is 0.2 while coefficient of friction between B and the ground is 0.3. The minimum required force F to start moving B will be:-



(A) 900 N (B) 100 N

(C) 1100 N (D) 1200N

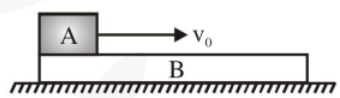
Q12. A 40 kg slab rests on a frictionless floor. A 10 kg block rests on top of the slab, fig. The static coefficient of friction between the block and the slab is 0.60 while the kinetic coefficient is 0.40. The 10 kg block is acted upon by a horizontal force of 100N. If g = 9.8 m/s^2, the resulting acceleration of the slab will be :-



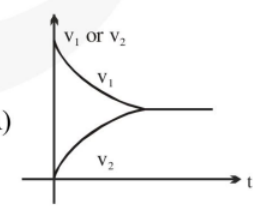
(A) 0.98 m/s^2 (B) 1.47 m/s^2

(C) 1.52 m/s^2 (D) 6.1 m/s^2

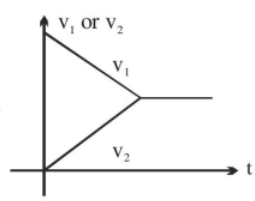
Q13. A block A is placed over a long rough plank B of same mass as shown in figure. The plank is placed over a smooth horizontal surface. At time t = 0, block A is given a velocity v_0 in horizontal direction. Let v_1 and v_2 be the velocities of A and B at time t. Then choose the correct graph between v_1 or v_2 and t.



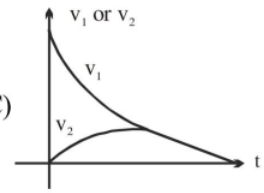
(A)



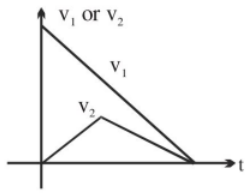
(B)



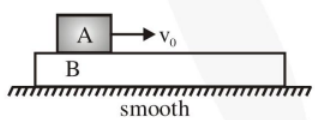
(C)



(D)



Q14. A block A of mass m is placed over a plank B of mass 2 m. Plank B is placed over a smooth horizontal surface. The coefficient of friction between A and B is 0.5. Block A is given a velocity v_0 towards right. Acceleration of B relative to A is :-



(A) $\frac{g}{2}$ (B) g (C) $\frac{3g}{4}$ (D) zero

Angle of Repose

Q15. A block is at rest on an inclined plane making an angle α with the horizontal. As the angle α of the incline is increased, the block starts slipping when the angle of inclination becomes θ. The coefficinet of static friction between the block and the surface of the inclined plane is :-

(A) $\sin\theta$ (B) $\cos\theta$
(C) $\tan\theta$ (D) $\cot\theta$

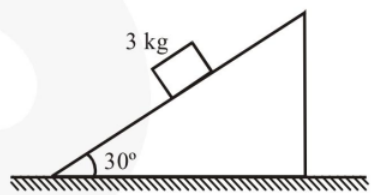
Q16. A block is pushed with some velocity up a rough inclined plane. It stops after ascending few meters and then reverses its direction and returns back to point from where it started. If angle of inclination is 37° and the time to climb up is half of the time to return back then coefficient of friction is :

(A) $\frac{9}{20}$ (B) $\frac{7}{5}$

(C) $\frac{7}{12}$ (D) $\frac{5}{7}$

Net Contact Force

Q17. A block of mass 3 kg is at rest on a rough inclined plane as shown in the figure. The magnitude of net force exerted by the surface on the block will be ($g=10\ m/s^2$)



(A) 26 N (B) 19.5 N
(C) 10 N (D) 30 N

Exercise - 1A — *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Which of the following is/are correct :-

(A) Kinetic friction is self adjustible.

(B) Friction always oppose motion.

(C) Friction may cause motion.

(D) Kinetic Friction opposes relative motion

Q2. A block is kept on a rough horizontal surface as shown. Its mass is 2 kg and coefficient of friction between block and surface (μ) = 0.5. A horizontal force F is acting on the block. When

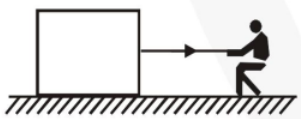
(A) F = 4 N, acceleration is zero.

(B) F = 4 N, friction is 10 N and acceleration is 3 m/s^2.

(C) F = 14 N, acceleration is 2 m/s^2.

(D) F = 14 N, friction is 14 N.

Q3. A man pulls a block heavier than himself with a light rope. The coefficient of friction is the same between the man and the ground and between the block and the ground. Then



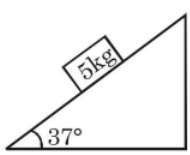
(A) block will never move

(B) the man can move even when the block is stationary

(C) if both move $a_{man} > a_{block}$

(D) none of these

Q4. A block of mass "5kg" is placed on a wedge having inclination of 37° with the horizontal. Coefficient of friction between block and wedge is 0.8. Then select the correct statement(s) :



(A) Friction force between block and the wedge is 32 N.

(B) Friction force between block and the wedge is 30 N.

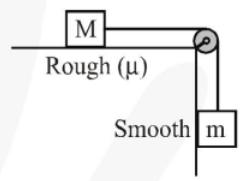
(C) Contact force between block and wedge is 50 N.

(D) Contact force between block and wedge is 40 N.

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

In figure, two blocks M and m are tied together with an inextensible and light string. The mass M is placed on a rough horizontal surface with coefficient of friction μ and the mass m is hanging vertically against a smooth vertical wall. The pulley is frictionless.



Q5. Choose the correct statement(s) :

(A) The system will accelerate for any value of m

(B) The system will accelerate only when m > M

(C) The system will accelerate only when m > μM

(D) Nothing can be said

Q6. Choose the correct statement(s) related to the tension T in the string.

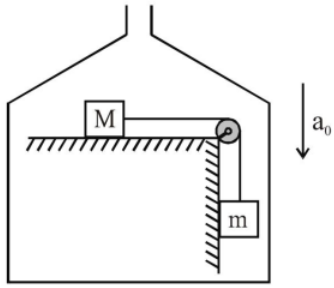
(A) When m < μM, T = mg

(B) When m < μM, T = Mg

(C) When m > μM, μMg < T < mg

(D) When m > μM, mg < T < μMg

Q7. Imagine a situation in which the given arrangement is placed inside an elevator that can move only in the vertical direction and compare the situation with the case when it is placed on the ground. When the elevator accelerates downward with a_0 (< g), then -



(A) The limiting friction force between the block M and the surface decreases

(B) The system can accelerate with respect to the elevator even when $m < \mu M$

(C) The system does not accelerate with respect to the elevator unless $m > \mu M$

(D) The tension in the string decreases

Q8. When the downward acceleration of the elevator becomes equal to g, then -

(A) Both the blocks remain stationary with respect to the elevator

(B) Both the blocks accelerate vertically downwards with g with respect to ground

(C) The tension in the string becomes equal to zero

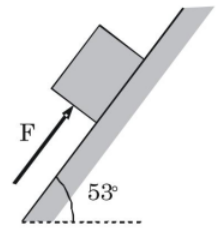
(D) The friction force between the block M and the surface is zero

MATCHING LIST TYPE

*Each question has TWO (02) **matching lists : LIST I and LIST II**. FOUR options are given representing matching of elements from from LIST I and LIST II. ONLY ONE of these four options corresponds to a correct matching. For each question, choose the option corresponding to the correct matching.*

Q9. A 50 kg box is held at rest on a slope of inclination 53° above the horizontal. It is released and immediately pushed by a force F up the slope. Coefficients of static and kinetic friction between the slope and the box are 0.5 and 0.4 respectively.

[$g = 10\ m/s^2$]



List-I (Magnitude of force F)	List-II (Friction force)
(P) 50 N	(1) 150 N up the slope
(Q) 150 N	(2) 50 N up the slope
(R) 250 N	(3) 120 N up the slope
(S) 350 N	(4) 400 N up the slope

Code :

	P	Q	R	S
(A)	1	1	2	4
(B)	2	4	3	1
(C)	3	3	1	2
(D)	3	2	1	4

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q10. A block is moving on an inclined plane making an angle of 45° with the horizontal surface and the coefficient of friction is μ. The force required to push up the inclined plane, is 3 times the force required to prevent it from sliding down. If we define $N = 10\ \mu$, then find the value of N.

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

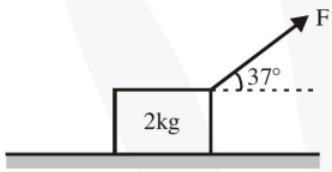
Q1. A block of mass 2 kg is kept on a rough horizontal floor and pulled with a force F. If the coefficient of friction is 0.5. then the minimum force required to move the block is

(A) 10 N

(B) $\frac{100}{11}$ N

(C) $\frac{100}{8}$ N

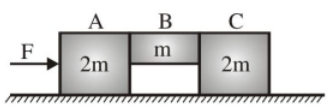
(D) 20 N



Q2. The rear side of a truck is open and a box of mass 20 kg is placed on the truck 4 m away from the open end, $\mu = 0.15$ and $g=10\ m/s^2$. The truck starts from rest with an acceleration of $2m/s^2$ on a straight road. The distance moved by the truck when box starts fall down is

(A) 4 m (B) 8 m (C) 16 m (D) 32 m

Q3. The system is pushed by a force F as shown in figure. All surfaces are smooth except between B and C. Friction coefficient between B and C is μ. Minimum value of F to prevent block B from downward slipping is :-



(A) $\left(\frac{3}{2\mu}\right)mg$ (B) $\left(\frac{5}{2\mu}\right)mg$

(C) $\left(\frac{5}{2}\right)\mu mg$ (D) $\left(\frac{3}{2}\right)\mu mg$

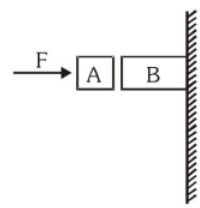
Q4. Given in the figure are two blocks A and B of weight 20 N and 100 N, respectively. These are being pressed against a wall by a force F as shown. If the coefficient of friction between the blocks is 0.1 and between block B and the wall is 0.15, the frictional force applied by the wall on block B is

(A) 120 N

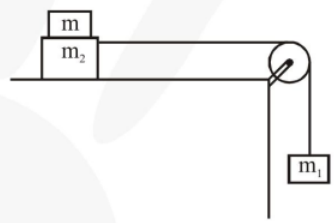
(B) 150 N

(C) 100 N

(D) 80 N



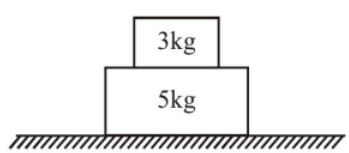
Q5. In figure coefficient of friction between m_2 and the horizontal surface is μ, minimum value of m so that the system has zero acceleration, is :-



(A) $\mu(m_1 + m_2)$ (B) $\mu(m_1 - m_2)$

(C) $m_2 - \frac{m_1}{\mu}$ (D) $\frac{m_1}{\mu} - m_2$

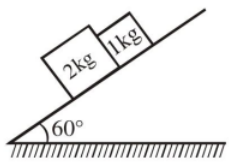
Q6. Two blocks are placed on a horizontal surface as shown in the figure. The coefficient of friction between the blocks is 0.5 and between block of 5 kg and the surface is 0.7. The maximum horizontal force that can be applied to the block of mass 5 kg so that the two blocks move without slipping is : (Take $g = 10\ m/s^2$)



(A) 14 N (B) 24 N

(C) 56 N (D) 96 N

Q7. In the figure shown if friction coefficient of block 1kg and 2kg with inclined plane is μ_1=0.5 and μ_2 = 0.4 respectively, then



(A) both block will move together.

(B) both block will move separately.

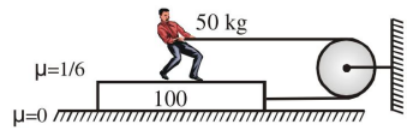
(C) there is a non zero contact force between two blocks.

(D) none of these

Q8. The time taken by a body to slide down a rough 45° inclined plane is twice that required to slide down a smooth 45° inclined plane. The cofficient of kinetic friction between the object and rough plane is given by :-

(A) $\frac{1}{3}$ (B) $\frac{3}{4}$ (C) $\sqrt{\frac{3}{4}}$ (D) $\sqrt{\frac{4}{3}}$

Q9. A man of mass 50 kg is pulling on a plank of mass 100 kg kept on a smooth floor as shown with force of 100 N. If both man & plank move together, find force of friction acting on man.



(A) $\frac{100}{3}$ N towards left

(B) $\frac{100}{3}$ N towards right

(C) $\frac{250}{3}$ N towards left

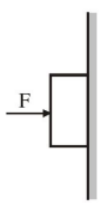
(D) $\frac{250}{3}$ N towards right

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A block of mass 1 kg is held at rest against a rough vertical surface by pushing by a force F horizontally. The coefficient of friction is 0.5. When



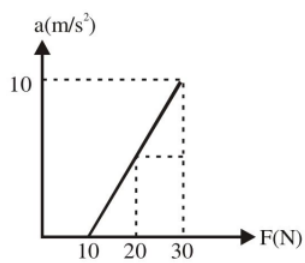
(A) F = 40 N, friction on the block is 20 N.

(B) F = 30 N, friction on the block is 10 N.

(C) F = 20 N, friction on the block is 10 N.

(D) Minimum value of force F to keep block at rest is 20 N.

Q2. A block placed on a rough horizontal surface is pushed with a force F acting horizontally on the block. The magnitude of F is increased and acceleration produced is plotted in the graph shown.



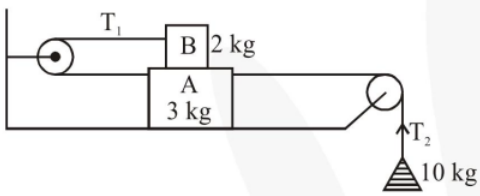
(A) Mass of the block is 2 kg.

(B) Coefficient of friction between block and surface is 0.5.

(C) Limiting friction between block and surface is 10 N.

(D) When $F = 8$ N, friction between block and surface is 10 N.

Q3. In the figure block A and B are of masses 3kg and 2kg. The coefficient of friction between the two blocks A and B is 0.3. The surface of the table is smooth. Then:-



(a) The acceleration of masses is 5.86 ms^{-2}

(b) The tensions are T_1 and T_2 in the strings are 90.36 N and 17.55 N

(c) Acceleration of masses is 8.15 ms^{-2}

(d) Tension T_1 and T_2 in the strings are 17.72 N and 41.4 N

(A) a, c (B) c, d

(C) b, d (D) a, d

Q4. A block is kept on a rough surface and applied with a horizontal force as shown which is gradually increasing from zero. The coefficient of static and kinetic friction are $1/\sqrt{3}$ then

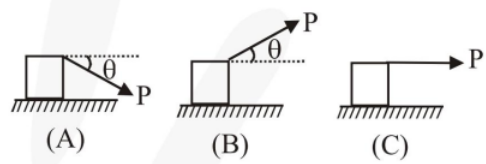
(A) When F is less than the limiting friction, angle made by net force on the block by the surface is less than 30° with vertical.

(B) When the block is just about to move, the angle made by net force by the surface on the block becomes equal to 30° with vertical.

(C) When the block starts to accelerate, the angle made by net force by the surface on the block becomes constant and equal to 30° vertical.

(D) The angle made by net force with vertical on the block by the surface, depends on the mass of the block.

Q5. Figure shows three blocks on a rough surface under influence of a force P of same magnitude in all the three cases. Coefficient of friction is same between each block and ground. What possible relation holds between magnitudes of normal reaction and friction forces. (Assume that blocks do not overturn about edge.) Here, f_A, f_B & f_C are frictional forces & N_A, N_B & N_C are reactions.



(A) $N_A > N_C > N_B$ (B) $f_A > f_C > f_B$

(C) $f_C > f_A = f_B$ (D) $N_C > N_A = N_B$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 6 to 10

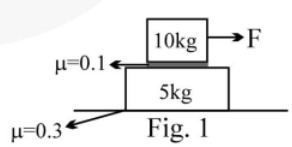


Fig. 1

Q6. When $F = 2$N, the frictional force between 5 kg block and ground is :

(A) 2N (B) 0

(C) 8 N (D) 10 N

Q7. When $F = 2N$, the frictional force between 10 kg block and 5 kg block is :

(A) 2N (B) 15 N

(C) 10 N (D) None

Q8. The maximum F which will not cause motion of any of the blocks is

(A) 10 N (B) 15 N

(C) data insufficient (D) None

Q9. The maximum acceleration of 5 kg block is

(A) 1 m/s^2 (B) 3 m/s^2

(C) 0 (D) None

Q10. The acceleration of 10 kg block when $F = 30$ N is

(A) 2 m/s^2 (B) 3 m/s^2

(C) 1 m/s^2 (D) None

Answer Key

Ex-1											
1	2	3	4	5	6	7	8	9	10	11	12
A	A	A	A	A	A	D	C	A	A	C	A
13	14	15	16	17							
B	C	C	A	D							

Ex- 1A

1. C,D **2.** A,C **3.** B,C **4.** B,C **5.** C

6. A,C **7.** A,C,D **8.** A,B,C,D **9.** C **10.** 5

Ex-2								
1	2	3	4	5	6	7	8	9
B	C	B	A	D	D	B	B	A

Ex- 2A

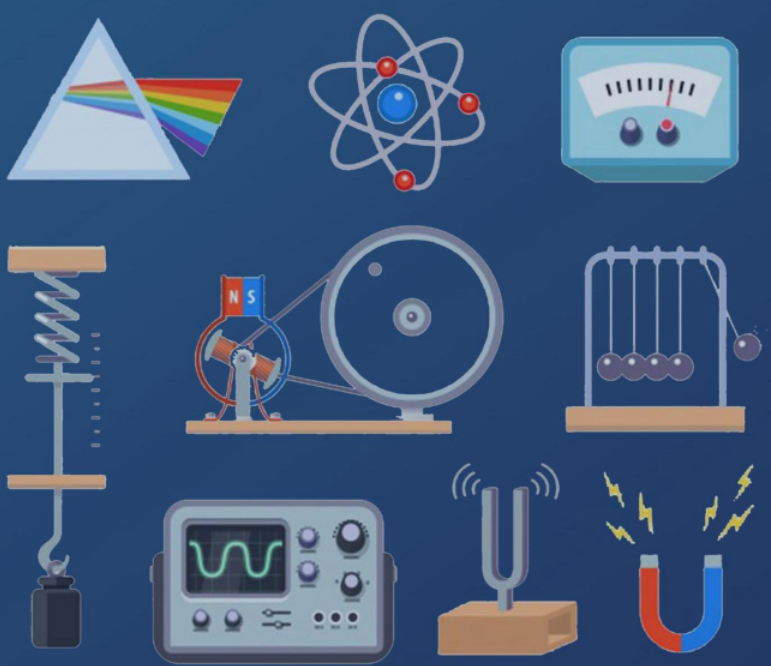
1. B,C,D **2.** A,B,C **3.** D **4.** A,B,CD **5.** A,B,C

6. A **7.** A **8.** A **9.** C **10.** A

-: Important Notes & Formulas :-

PHYSICS

Gravitation



SHEET

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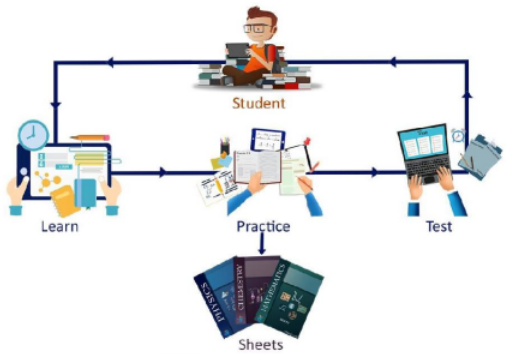
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Universal Law of Gravitation	1-3	14	1,2	1
2	Gravitational Field	4-6	1	3	17
3	Acceleration due to Gravity	7-9	13	4,5	2,3,18
4	Gravitational Potential Energy and Potential	10-12	2-4,11	6	
5	Motion of Satellite	13-20	5,6,12,15	7-9	4-6,12-14
6	Kepler's Laws	21-23	7,9,10,16,17	10-12	7,15,16
7	Escape Velocity	24-29		13,14	8,9
8	Weightlessness	30		15	10
9	After full chapter		8	16	11,19,20

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Universal Law of Gravitation

Q1. The mass of the moon is 1% of mass of the earth. The ratio of gravitational pull of earth on moon to that of moon on earth will be:-

(A) 1 : 1

(B) 1 : 10

(C) 1 : 100

(D) 2 : 1

Q2. Three identical point masses, each of mass 1 kg lie in the x–y plane at points (0, 0) (0, 0.2m) and (0.2m,0). The gravitational force on the mass at the origin is :–

(A) $1.67 \times 10^{-11}\ (\hat{i}+\hat{j})N$

(B) $3.34 \times 10^{-10}\ (\hat{i}+\hat{j})N$

(C) $1.67 \times 10^{-9}\ (\hat{i}+\hat{j})N$

(D) $3.34 \times 10^{-10}\ (\hat{i}-\hat{j})N$

Q3. Four particles of masses m, 2m, 3m and 4m are kept in sequence at the corners of a square of side a. The magnitude of gravitational force acting on a particle of mass m placed at the centre of the square will be :

(A) $\frac{24m^2G}{a^2}$ (B) $\frac{6m^2G}{a^2}$

(C) $\frac{4\sqrt{2}Gm^2}{a^2}$ (D) Zero

Gravitational Field

Q4. The radius of Earth is about 6400 km and that of mars is 3200 km. The mass of the Earth is 10 times the mass of mars. An object weight 200 N on the surface of Earth. Its weight on the surface of mars will be :–

(A) 80 N (B) 40 N (C) 20 N (D) 8 N

Q5. The acceleration due to gravity g and mean density of earth ρ are related by which of the following relations? [G = gravitational constant and R = radius of earth] :

(A) $\rho=\frac{4\pi gR^2}{3G}$ (B) $\rho=\frac{4\pi gR^3}{3G}$

(C) $\rho=\frac{3g}{4\pi GR}$ (D) $\rho=\frac{3g}{4\pi GR^3}$

Q6. If the radius of the earth be increased by a factor of 5, by what factor its density be changed to keep the value of g the same?

(A) 1/25 (B) 1/5 (C) $1/\sqrt{5}$ (D) 5

Acceleration due to Gravity

Q7. A stone drop from height 'h' reaches to earth surface in1 sec. If the same stone taken to moon and drop freely then it will reaches from the surface of the moon in the time :–

(A) $\sqrt{6}$ sec (B) 9 sec

(C) $\sqrt{3}$ sec (D) 6 sec

Q8. Consider the earth to be a homogenous sphere, scientist A goes deep down in a mine and scientist B goes high up in a ballon. The gravitation field measured by :–

(A) A goes a decreasing and the by B goes an increasing

(B) B goes a decreasing and that by A goes a increasing

(C) each remains unchanged

(D) each goes on decreasing

Q9. Gravitation on moon is $1/6^{th}$ of that on earth. When a balloon filled with hydrogen is released on moon then this :-

(A) Will rise with an acceleration less than $\left(\frac{g}{6}\right)$

(B) Will rise with acceleration $\left(\frac{g}{6}\right)$

(C) Will fall down with an acceleration less than $\left(\frac{5g}{6}\right)$

(D) Will fall down with acceleration $\left(\frac{g}{6}\right)$

Gravitational Potential Energy and Potential

Q10. A body attains a height equal to the radius of the earth when projected from earth' surface. The velocity of the body with which it was projected is :–

(A) $\sqrt{\frac{GM}{R}}$ (B) $\sqrt{\frac{2GM}{R}}$

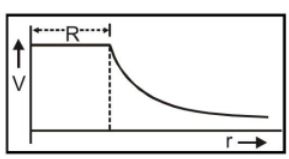
(C) $\sqrt{\frac{5}{4}\frac{GM}{R}}$ (D) $\sqrt{\frac{3GM}{R}}$

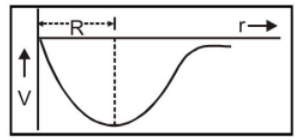
Q11. The gravitational potential energy of a body at a distance r from the center of the earth is U. The gravitational force at that point is :-

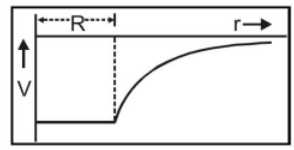
(A) $\frac{U}{r^2}$ (B) $\frac{U}{r}$

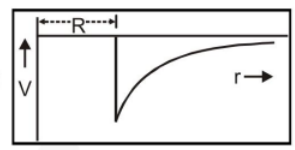
(C) Ur (D) Ur^2

Q12. Which of the following waves expresses the variation of gravitational potential with distance for a hollow sphere of radius R :

(A) 

(B) 

(C) 

(D) 

Motion of Satellite

Q13. What will be velocity of a satellite revolving around the earth at a height h above surface of earth if radius of earth is R :-

(A) $R^2\sqrt{\frac{g}{R+h}}$ (B) $R\frac{g}{(R+h)^2}$

(C) $R\sqrt{\frac{g}{R+h}}$ (D) $R\sqrt{\frac{R+h}{g}}$

Q14. Two identical satellites are at the heights R and 7R from the earth's surface. Then which of the following statement is incorrect :–

(R = radius of the earth)

(A) ratio of kinetic energy of both is 4

(B) ratio of total energy of both is 5

(C) ratio of potential energy of both 4

(D) ratio of total energy of both is 4

Q15 Two artificial satellites of masses m_1 and m_2 are moving with speeds v_1 and v_2 in orbits of radii r_1 and r_2 respectively. If $r_1 > r_2$ then which of the following statements is true :–

(A) $v_1 = v_2$ (B) $v_1 > v_2$

(C) $v_1 < v_2$ (D) $\frac{v_1}{r_1} = \frac{v_2}{r_2}$

Q16. Two artificial satellites A and B are at a distance r_A and r_B above the earth's surface. If the radius of earth is R, then the ratio of their speed will be :–

(A) $\left[\frac{r_B+R}{r_A+R}\right]^{1/2}$ (B) $\left[\frac{r_B+R}{r_A+R}\right]^{2}$

(C) $\left[\frac{r_B}{r_A}\right]^{2}$ (D) $\left[\frac{r_B}{r_A}\right]^{1/2}$

Q17. One projectile after deviating from its path starts moving round the earth in a cirular path of radius equal to nine times the radius of earth R. Its time period will be :

(A) $2\pi\sqrt{\frac{R}{g}}$ (B) $27\times 2\pi\sqrt{\frac{R}{g}}$

(C) $\pi\sqrt{\frac{R}{g}}$ (D) $0.8\times 3\pi\sqrt{\frac{R}{g}}$

Q18. A satellite is moving in a circular orbit around earth with a speed v, If its mass is m, then its total energy will be :

(A) $\frac{3}{4}mv^2$ (B) mv^2

(C) $\frac{1}{2}mv^2$ (D) $-\frac{1}{2}mv^2$

Q19. The relay satellite transmits the television programme continuously from one part of the world to another because its :

(A) Period is greater than the period of rotation of the earth about its axis

(B) Period is less than the period of rotation of the earth about its axis

(C) Period is equal to the period of rotation of the earth about its axis

(D) Mass is less than the mass of earth

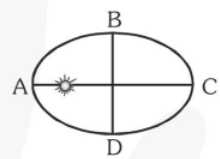
Q20. The gravitational force between two bodies is directly proportional to $\frac{1}{R}$ (not $\frac{1}{R^2}$), where 'R' is the distance between the bodies. Then the orbital speed for this force in circular orbit is proportional to :-

(A) $1/R^2$ (B) R^0

(C) R (D) 1/R

Kepler's Laws

Q21. In adjoining figure earth goes around the sun in elliptical orbit on which point the orbital speed is maximum :-



(A) on A (B) on B

(C) on C (D) on D

Q22. A planet is revolving around the Sun in an elliptical orbit. Its closest distance from the Sun is r_{min}. The farthest distance from the Sun is r_{max}. If the orbital angular velocity of the planet when it is nearest to the Sun is ω, then the orbital angular velocity at the point when it is at the farthest distance from the Sun is–

(A) $\left(\sqrt{\frac{r_{min}}{r_{max}}}\right)\omega$ (B) $\left(\sqrt{\frac{r_{max}}{r_{min}}}\right)\omega$

(C) $\left(\frac{r_{max}}{r_{min}}\right)^2\omega$ (D) $\left(\frac{r_{min}}{r_{max}}\right)^2\omega$

Q23. A planet of mass m is in an elliptical orbit about the sun ($m << M_{sun}$) with an orbital period T. If A be the area of orbit, then its angular momentum would be :

(A) $\frac{2mA}{T}$ (B) mAT

(C) $\frac{mA}{2T}$ (D) 2mAT

Escape Velocity

Q24. Escape velocity of a body from the surface of the earth is 11.2 km/s. Escape velocity, when thrown at an angle of 45° from horizontal will be :–

(A) 11.2 km/s (B) 22.4 km/s

(C) $\frac{11.2}{\sqrt{2}}$ km/s (D) $11.2\sqrt{2}$ km/s

Q25. Escape velocity from earth is 11.2 km/sec. Another planet of same mass has radius $\frac{1}{4}$ times that of earth. What is the escape velocity from this planet ?

(A) 11.2 km/sec (B) 44.8 km/sec

(C) 22.4 km/sec (D) 5.6 km/sec

Q26. A body of mass m is situated at distance $4R_e$ above the Earth's surface, where R_e is the radius of Earth. How much minimum energy be given to the body so that it may escape?

(A) mgR_e (B) $2mgR_e$

(C) $\frac{mgR_e}{5}$ (D) $\frac{mgR_e}{16}$

Q27. The ratio of radii of two satellites is p and the ratio of their acceleration due to gravity is q. The ratio of their escape velocities will be :

(A) $\left(\frac{q}{p}\right)^{1/2}$ (B) $\left(\frac{p}{q}\right)^{1/2}$

(C) pq (D) $\sqrt{pq}$

Q28. A missile is launched with a velocity less than the escape velocity. Sum of its kinetic energy and potential energy is :-

(A) Positive

(B) Negative

(C) May be negative or positive depending upon its initial velocity

(D) Zero

Q29. **Statement – 1 :** Escape velocity is independent of the angle of projection.

Statement – 2 : Escape velocity for vertical projection from the surface of Earth is $\sqrt{\frac{2GM}{R}}$.

(A) Statement-1 is True, Statement–2 is True; Statement-2 is a correct explanation for Statement-1.

(B) Statement-1 is True, Statement–2 is True; Statement-2 is not a correct explanation for Statement-1.

(C) Statement-1 is True, Statement-2 is False.

(D) Statement-1 is False, Statement-2 is True.

Weightlessness

Q30. **Statement – 1:** An astronaut in an orbiting space station above the Earth experiences weightlessness.

Statement – 2 : An object moving around the Earth under the influence of Earth's gravitational force is in a state of 'free-fall'.

(A) Statement-1 is True, Statement-2 is True; Statement-2 is a correct explanation for Statement1

(B) Statement-1 is True, Statement-2 is True; Statement-2 is Not a correct explanation for Statement1

(C) Statement-1 is True, Statement-2 is False

(D) Statement-1 is False, Statement-2 is True

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The magnitudes of the gravitational field at distance r_1 and r_2 from the centre of a uniform, sphere of radius R and mass M are F_1 and F_2 respectively. then :–

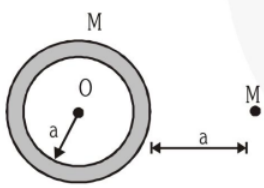
(A) $\frac{F_1}{F_2}=\frac{r_1}{r_2}$ if $r_1 < R$ and $r_2 < R$

(B) $\frac{F_1}{F_2}=\frac{r_2^2}{r_1^2}$ if $r_1 > R$ and $r_2 > R$

(C) $\frac{F_1}{F_2}=\frac{r_1^3}{r_2^3}$ if $r_1 < R$ and $r_2 < R$

(D) $\frac{F_1}{F_2}=\frac{r_1^2}{r_2^2}$ if $r_1 < R$ and $r_2 < R$

Q2. A particle of mass M is at a distance a from surface of a thin spherical shell of equal mass and having radius a :



(A) Gravitational field and potential both are zero at centre of the shell

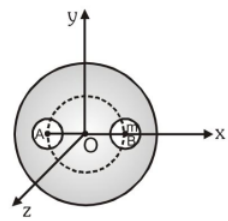
(B) Gravitational field is zero not only inside the shell but at a point outside the shell also

(C) Inside the shell, gravitational field alone is zero

(D) Neither gravitational field nor gravitational potential is zero inside the shell

Q3. A solid sphere of uniform density and radius 4 units is located with its centre at the origin O of coordinates. Two spheres of equal radii 1 unit, with their centres at A (–2, 0, 0) and B (2,0,0) respectively, are taken out of the solid leaving behind spherical cavities as shown in figure.

Then :-



(A) The gravitational field due to this object at the origin is zero

(B) The gravitational field at the point B(2, 0, 0) is zero

(C) The gravitational potential is the same at all points of circle $y^2 + z^2 = 36$

(D) The gravitational potential is the same at all points on the circle $y^2 + z^2 = 4$

Q4. Gravitational potential at the centre of curvature of a hemispherical bowl of radius R and mass M is V :-

(A) Gravitational potential at the centre of curvature of a thin uniform wire of mass M, bent into a semicircle of radius R, is also equal to V

(B) In part (A) if the same wire is bent into a quarter of a circle then also the gravitational potential at the centre of curvature will be V

(C) In part (A) if the wire mass is non uniformly distributed along its length audit is bent into a semicircle of radius R, gravitational potential at the centre is V

(D) None of these

Q5. For a satellite to be geo–stationary, which of the following is/are essential conditions?

(A) It must always be stationed above the equator and it's time period must be 24 hours.

(B) It must be rotated from west to east

(C) It must be about 36000 km above the Earth

(D) Its orbit must be circular, and not elliptical

Q6. The Sun travels in approximately circular orbit of radius R around the center of the galaxy and completes one revolution in time T. The Earth also revolves around the Sun in time t. Assume orbit of the Earth to be a circle of radius r ($r << R$) and whole mass of the galaxy centered on its center. By using only these given informations, find an expression for the ratio of the mass of the galaxy to that of the Sun.

(A) $\left(\frac{R}{r}\right)^3\left(\frac{t}{T}\right)^2$ (B) $\left(\frac{R}{r}\right)^3\left(\frac{T}{t}\right)^2$

(C) $\left(\frac{R}{r}\right)^2\left(\frac{t}{T}\right)^3$ (D) $\left(\frac{R}{r}\right)^2\left(\frac{T}{t}\right)^3$

Q7. When a satellite in a circular orbit around the Earth enters the atmospheric region, it encounters small air resistance to its motion. Then

(A) Its kinetic energy increases

(B) Its kinetic energy decreases

(C) Its angular momentum about the Earth decreases

(D) Its period of revolution around the Earth increases

Q8. A double star is a system of two stars of masses m and 2m, rotating about their centre of mass only under their mutual gravitational attraction. If r is the separation between these two stars then their time period of rotation about their centre of mass will be proportional to :

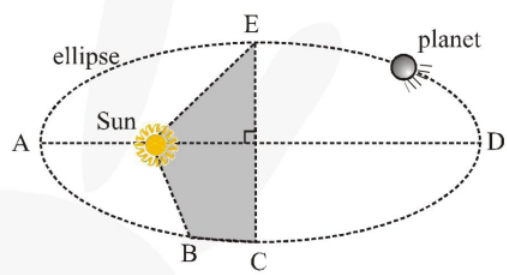
(A) $r^{3/2}$ (B) r (C) $m^{1/2}$ (D) $m^{-1/2}$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 9 & 10

In the picture below, the planet orbits around the sun with a period of 40 months and takes 12 months to translate from the point D to point E and 1 month from point B to C. The area of the ellipse is A. Mass of the satellite is m.



Q9. The area of the shaded region

(A) A/20 (B) A/8

(C) A/40 (D) A/4

Q10. The angular momentum of satellite per unit mass per unit area is

(A) 5×10^{-8} /s (B) 16×10^{-8} /s

(C) 2×10^{-8} /s (D) Zero

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q11.

Column–I	Column–II
(A) Kinetic energy of a particle in gravitational field is increasing	(P) work done by gravitational force should be positive
(B) Potential energy of a particle in gravitational field is increasing	(Q) work done by external force should be non zero
(C) Mechanical energy of a particle in gravitational field is increasing	(R) work done by gravitational force should be negative
	(S) can not say anything

Q12. A satellite is in a circular equatorial orbit of radius 7000 km around the Earth. If it is transferred to a circular orbit of double the radius

Column I	Column II
(A) Angular momentum	(P) Increases
(B) Area of Earth covered by satellite signal	(Q) Decreases
(C) Potential energy	(R) Becomes double
(D) Kinetic energy	(S) Becomes half

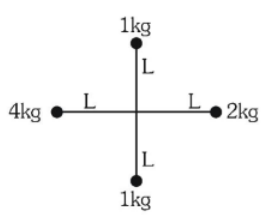
NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q13. How much below the surface does in Km the acceleration due to gravity becomes 70% of its value on the surface of earth?

SUBJECTIVE TYPE

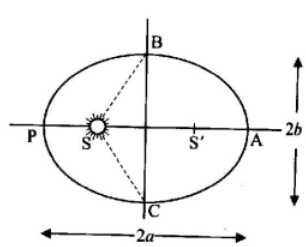
Q14. In the given figure, L = 1 metre, if total gravitational force on 4 kg mass is $\vec{F}_1$ and on 2 kg mass is $\vec{F}_2$, then find out the ratio of $\left|\frac{\vec{F}_1}{\vec{F}_2}\right|$.



Q15. A satellite of mass m is orbiting the earth in a circular orbit of radius r. It starts losing energy due to small air resistance at the rate of C J/ s. Then the time taken for the satellite to reach the earth is _____.

Q16. A comet orbits the sun in a highly elliptical orbit. Does the comet have a constant (a) linear speed, (b) angular speed, (c) angular momentum, (d) kinetic energy, (e) potential energy, (f) total energy throught out its orbit ? Neglect any mass loss of the comet when it comes very close to the Sun.

Q17. Let the speed of the planet at the perihelion P in Fig. be v_p and the Sun-planet distance SP be r_p. Relate (r_p, v_p) to the corresponding quantities at the aphelion (r_A, v_A). Will the planet take equal times to travel BAC and CPB ?



SINGLE CORRECT TYPE

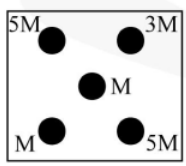
*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

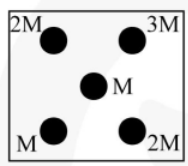
Q1. Three identical bodies (each of mass M) are placed at vertics of an equilateral triangle of arm L, keeping the triangle as such, by which angular speed the bodies should be rotated in their gravitation fields so that the triangle moves along circumferenes of circular orbit:

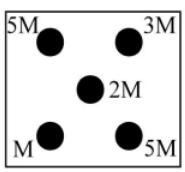
(A) $\sqrt{\frac{3GM}{L^3}}$ (B) $\sqrt{\frac{GM}{L^3}}$

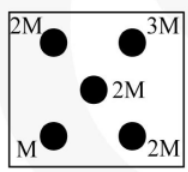
(C) $\sqrt{\frac{GM}{3L^3}}$ (D) $3\sqrt{\frac{GM}{L^3}}$

Q2. A mass is at the center of a square, with four masses at the corners as shown. Rank the choices according to the magnitude of the gravitational force on the center mass.

(A) 

(B) 

(C) 

(D) 

(A) $F_A = F_B < F_C = F_D$
(B) $F_A > F_B < F_D < F_C$
(C) $F_A = F_B > F_C = F_D$
(D) None

Q3. If the distance between the centres of earth and moon is D and mass of earth is 81 times that of moon. At what distance from the centre of earth gravitational field will be zero :-

(A) $\frac{D}{2}$ (B) $\frac{2D}{3}$ (C) $\frac{4D}{5}$ (D) $\frac{9D}{10}$

Q4. A planet whose mass and radius are both half of that of earth . Acceleration due to gravity (g) at its surface should be :-

(A) 29.4 m/sec^2 (B) 19.6 m/sec^2
(C) 9.8 m/sec^2 (D) 4.9 m/sec^2

Q5. The value of 'g' reduces to half of its value at surface of earth at a height 'h', then :–

(A) $h = R$
(B) $h = 2R$
(C) $h = (\sqrt{2}+1)R$
(D) $h = (\sqrt{2}-1)R$

Q6. If the gravitational acceleration at surface of earth is g, then increase in potential energy in lifting an object of mass m to a height equal to the radius R_e of earth will be:–

(A) $\frac{mgR_e}{2}$ (B) $2mgR_e$
(C) mgR_e (D) $\frac{mgR_e}{4}$

Q7. If the length of the day is T, the height of that TV satellite above the earth's surface which always appears stationary from earth, will be :

(A) $h = \left[\frac{4\pi^2 GM}{T^2}\right]^{1/3}$

(B) $h = \left[\frac{4\pi^2 GM}{T^2}\right]^{1/2} - R$

(C) $h = \left[\frac{GMT^2}{4\pi^2}\right]^{1/3} - R$

(D) $h = \left[\frac{GMT^2}{4\pi^2}\right]^{1/3} + R$

Q8. A geostationary satellite orbits around the Earth in a circular orbit of radius 36,000 km. Then, the time period of a spy satellite orbiting a few hundred km (600 km) above the Earth's surface (R_e= 6400 km) will approximately be :-

(A) $\frac{1}{2}$ h (B) 1h

(C) 2h (D) 4h

Q9. If a graph is plotted between T^2 and r^3 for a planet then its slope will be :-

(A) $\frac{4\pi^2}{GM}$ (B) $\frac{GM}{4\pi^2}$

(C) 4π GM (D) zero

Q10. A planet is revolving round the sun. Its distance from the sun at Apogee is r_A and that at Perigee is r_p. The mass of planet and sun is m and M respectively, v_A and v_p is the velocity of planet at Apogee and Perigee respectively and T is the time period of revolution of planet round the sun.

(a) $T^2 = \frac{\pi^2}{2Gm}(r_A + r_P)^2$

(b) $T^2 = \frac{\pi^2}{2GM}(r_A + r_P)^3$

(c) $v_A r_A = v_P r_P$

(d) $v_A < v_P$, $r_A > r_P$

(A) a, b, c (B) a, b, d

(C) b, c, d (D) all

Q11. A satellite S is moving in an elliptical orbit around the Earth. The mass of the satellite is very small compared to the mass of the Earth :-

(A) The acceleration of S always directed towards the centre of the Earth

(B) The angular momentum of S about the centre of the Earth changes in direction, but its magnitude remain constant

(C) The total mechanical energy of S varies periodically with time

(D) The linear momentum of S remains constant in magnitude

Q12. A double star system consists of two stars A and B which have time period T_A and T_B. Radius R_A and R_B and mass M_A and M_B. Choose the correct option :-

(A) If $T_A > T_B$ then $R_A > R_B$

(B) If $T_A > T_B$ then $M_A > M_B$

(C) $\left(\frac{T_A}{T_B}\right)^2 = \left(\frac{R_A}{R_B}\right)^3$

(D) $T_A = T_B$

Q13. Two planets A and B have the same material density. If the radius of A is twice that of B, then the ratio of the escape velocity $\frac{v_A}{v_B}$ is-

(A) 2 (B) $\sqrt{2}$ (C) $1/\sqrt{2}$ (D) $1/2$

Q14. If velocity of a satellite is half of escape velocity, then distance of the satellite from earth surface will be :-

(A) 6400 km (B) 12800 km

(C) $6400\sqrt{2}$ km (D) $\frac{6400}{\sqrt{2}}$ km

Q15. If the angular speed of earth is increased so much that the objects start flying from equator, then the length of the day will be nearly :-

(A) $1\frac{1}{2}$ hour (B) 8 hour

(C) 18 hour (D) 24 hour

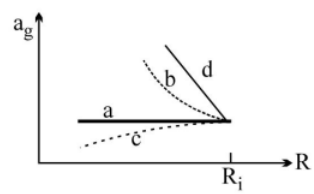
Q16. A (nonrotating) star collapses onto itself from an initial radius R_i with its mass remaining unchanged. Which curve in figure best gives the gravitational acceleration a_g on the surface of the star as a function of the radius of the star during the collapse?

(A) a

(B) b

(C) c

(D) d



MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Two masses m_1 and m_2 ($m_1 < m_2$) are released from rest from a finite distance. They start under their mutual gravitational attraction

(A) acceleration of m_1 is more than that of m_2

(B) acceleration of m_2 is more than that of m_1

(C) centre of mass of system will remain at rest in all the references frame

(D) total energy of system remains constant

Q2. At what altitude will the acceleration due to gravity be 25% of that at the earth's surface (given radius of earth is R)?

(A) R/4 (B) R

(C) 3R/8 (D) R/2

Q3. Let ω be the angular velocity of the earth's rotation about its axis. Assume that the acceleration due to gravity on the earth's surface has the same value at the equator and the poles in absence of rotation of earth. An object weighed at the equator gives the same reading as a reading taken at a depth d below earth's surface at a pole (d<<R) The value of d is

(A) $\frac{\omega^2 R^2}{g}$ (B) $\frac{\omega^2 R^2}{2g}$

(C) $\frac{2\omega^2 R^2}{g}$ (D) $\frac{\sqrt{Rg}}{g}$

Q4. A satellite is fired from the surface of the moon of mass M and radius R, with speed v_0 at 30° with the vertical. The satellite reaches a maximum distance of $\frac{5R}{2}$ from the centre of the moon. The value of v_0 is-

(A) $\sqrt{\frac{2GM}{R}}$ (B) $\sqrt{\frac{5GM}{2R}}$

(C) $\sqrt{\frac{5GM}{4R}}$ (D) $\sqrt{\frac{2GM}{37R}}$

Q5. Satellites A and B are orbiting around the earth in orbits of ratio R and 4R respectively. The ratio of their areal velocities is :

(A) 1 : 2 (B) 1 : 4

(C) 1 : 8 (D) 1 : 16

Q6. If a satellite orbits as close to the earth's surface as possible,

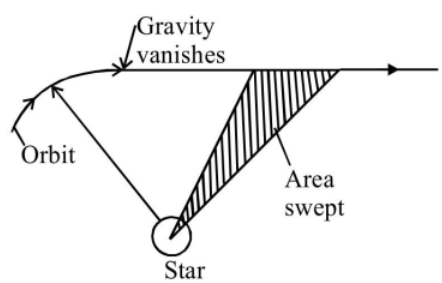
(A) Its speed is maximum

(B) Time period of its rotation is minimum

(C) The total energy of the 'earth plus satellite' system is minimum

(D) The total energy of the 'earth plus satellite'system is maximum

Q7. A planet is orbiting a star when for no apparent reason the star's gravity suddenly vanishes. After which planet moves in a straight line. Mark the **CORRECT** statement(s) :-



(A) Newton's first law is obeyed on planet after gravity vanishes

(B) Kepler's law of areas is obeyed only till the planet is in gravity of star

(C) Kepler's law of areas is obeyed even after gravity vanishes

(D) Angular momentum of planet about centre of star is conserved through out its motion

Q8. A spherical uniform planet is rotating about its axis. The velocity of a point on its equator is V. Due to the rotation of planet about its axis the acceleration due to gravity g at equator is 1/2 of g at poles. The escape velocity of a particle on the pole of planet in terms of V is

(A) $V_e = 2V$ (B) $V_e = V$

(C) $V_e = V/2$ (D) $V_e = \sqrt{3}\,V$

Q9. The escape velocity for a planet is v_e. A tunnel is dug along a diameter of the planet and a small body is dropped into it at the surface. When the body reaches the centre of the planet, its speed will be

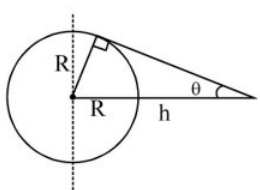
(A) v_e (B) $\frac{v_e}{\sqrt{2}}$

(C) $\frac{v_e}{2}$ (D) zero

Q10. The fractional change in the value of free–fall acceleration g for a particle when it is lifted from the surface to an elevation h (h<<R) is

(A) $\frac{h}{R}$ (B) $\frac{2h}{R}$ (C) $-\frac{2h}{R}$ (D) $-\frac{h}{R}$

Q11. A geostationary satellite is at a height h above the surface of earth. If earth radius is R.



(A) The minimum colatitude on earth upto which the satellite can be used for communication is $\sin^{-1}(R/R+h)$.

(B) The maximum latitudes on earth upto which the satellite can be used for communication is $\cos^{-1}(R/R+h)$.

(C) The area on earth escaped from this satellite is given as $2\pi R^2 (1 + \sin\theta)$

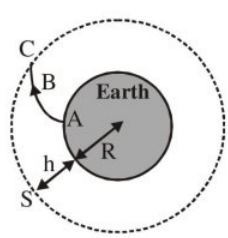
(D) The area on earth escaped from this satellite is given as $2\pi R^2 (1 + \cos\theta)$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question nos. 12 to 14

An Earth satellite is a body placed in a stable orbit about the Earth. These satellites are used for communications, meteorology, Earth measurements (gravitation and magnetic fields), resource evaluation (water, minerals), transmission of radio and TV signals, and as reference points for navigation. Although most satellites are launched from ground based stations, more recently some have been placed in orbit from one of NASA's space shuttles.There are two requirements needed to place a satellite in a stable orbit at an insertion point C. (Figure). It is first necessary to bring the satellite to that altitude and then the satellite must be given the necessary orbiting velocity. The orbiting velocity for a circular orbit, also called the insertion velocity.



Q12. What is insertion velocity for very small h (<<R)

(A) $\left(\frac{GM}{R}\right)^{1/2}\left[1-\frac{h}{2R}\right]$

(B) $\left(\frac{2GM}{R}\right)^{1/2}\left[1-\frac{h}{2R}\right]$

(C) $\left(\frac{GM}{R}\right)^{1/2}\left[1-\frac{2h}{R}\right]$

(D) $\left(\frac{GM}{2R}\right)^{1/2}\left[1-\frac{h}{2R}\right]$

Q13. If velocity at insertion point is k times escape velocity of the satellite at the insertion height h, then mark incorrect statement.

(A) For k =1 satellite moves in a circular orbit

(B) For k ≥1 satellite moves in an unbound orbit

(C) For k < 1 satellite may move in an elliptical orbit

(D) For k < 1 satellite can move in circular orbit

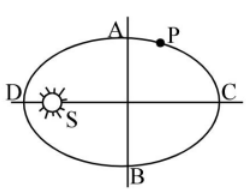
Q14. A particle is projected from surface of Earth with velocity v, such that it's total energy at height h becomes same as the total energy of a satellite, moving in circular orbit of same height. Value of v is

(A) $\sqrt{\frac{2GM}{R}}\left(1+\frac{h}{2R}\right)$ (B) $\sqrt{\frac{GM}{R}}\left(1+\frac{h}{2R}\right)$

(C) $\sqrt{\frac{2GM}{R}}\left(1-\frac{h}{2R}\right)$ (D) $\sqrt{\frac{GM}{R}}\left(1-\frac{h}{2R}\right)$

Paragraph for Question No. 15 & 16

Figure shows the orbit of a planet P around the sun S. AB and CD are the minor and major axes of the ellipse.



Q15. If t_1 is the time taken by the planet to travel along ACB and t_2 the time along BDA, then

(A) $t_1 = t_2$

(B) $t_1 > t_2$

(C) $t_1 < t_2$

(D) Nothing can be concluded

Q16. If U is the potential energy and K kinetic energy then |U| > |K| at

(A) Only D

(B) Only C

(C) both D & C

(D) neither D nor C

SUBJECTIVE TYPE

Q17. The gravitational field in a region is given by $\vec{E} = (3\hat{i} - 4\hat{j})$ N/kg. Find out the work done (in joule) in displacing a particle by 1 m, along the line 4y = 3x + 9 :

Q18. Calculate the distance from the surface of the earth at which above and below the surface acceleration due to gravity is the same.

Q19. A pair of stars rotates about a common center of mass. One of the stars has a mass M which is twice as large as the mass m of the other. Their centres are at a distance d apart, d being large compared to the size of either star.

(a) Derive an expression for the period of rotation of the stars about their common centre of mass in terms of d,m, G.

(b) Compare the angular momentum of the two stars about their common centre of mass by calculating the ratio L_m / L_M.

(c) Compare the kinetic energies of the two stars by calculating the ratio K_m/K_M.

Q20. In a particular double star system, two stars of mass 3.22×10^{30} kg each revolve about their common centre of mass, 1.12×10^{11} m away.

(i) Calculate their common period of revolution, in years.

(ii) Suppose that a meteoroid (small solid particle in space) passes through this centre of mass moving at right angles to the orbital plane of the stars. What must its speed be if it is to escape from the gravitational field of the double star?

Answer Key

Ex-1									
1	2	3	4	5	6	7	8	9	10
A	C	C	A	C	B	A	D	D	A
11	12	13	14	15	16	17	18	19	20
B	C	C	B	C	A	B	D	C	B
21	22	23	24	25	26	27	28	29	30
A	D	A	A	C	C	D	B	B	A

Ex-1A

1. A,B **2.** D **3.** A,C,D **4.** A,C **5.** A,B,C,D

6. A **7.** A,C **8.** A,D **9.** B **10.** C

11. (A)-S,(B)-R,(C)-Q **12.** (A)-P (B)-P (C)-P,S (D)-Q,S

13. 1920 km **14.** $\frac{F_1}{F_2} = \sqrt{2}$ **15.** $t = \frac{GMm}{2C}\left(\frac{1}{R_e} - \frac{1}{r}\right)$

16. All quantities vary over an orbit except angular momentum and total energy.

17. The planet will take a longer time to traverse BAC than CPB.

Ex-2									
1	2	3	4	5	6	7	8	9	10
A	A	D	B	D	A	C	C	A	C
11	12	13	14	15	16				
A	D	A	A	A	B				

Ex-2A

1. A,D **2.** B **3.** A **4.** C **5.** A

6. A,B,C **7.** A,C,D **8.** A **9.** B **10.** C

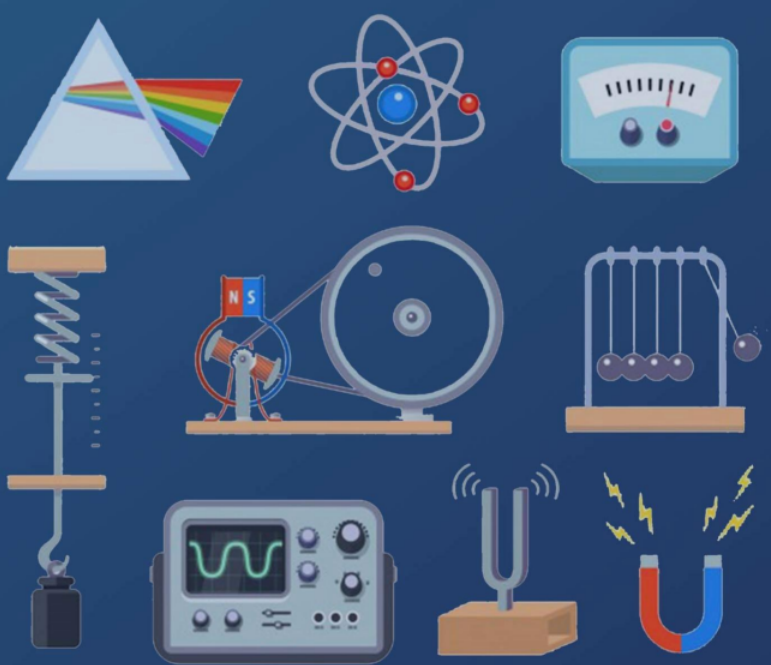
11. A,B,C **12.** A **13.** A **14.** B **15.** B

16. C **17.** 0 **18.** $h = \frac{\sqrt{5}-1}{2}R$

19. (a) $T = \frac{2\pi d^{3/2}}{\sqrt{3Gm}}$ (b) 2 (c) 2 **20.** (i) $T = 4\pi\sqrt{\frac{r^3}{GM}}$ (ii) $v = \sqrt{\frac{4GM}{r}}$; $\left(r = \frac{d}{2}\right)$

PHYSICS

Heat Transfer



SHEET

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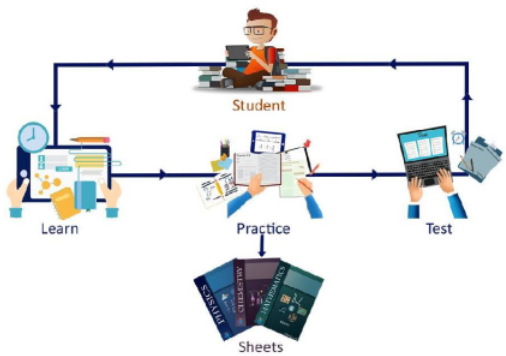
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Modes of Heat Transfer			1	1
2	Conduction-Introduction	1	1	2	
3	Thermal Resistance and Junction Rule	2-4	2,8	3,4	2,18
4	Conduction-Miscelleneous	5,6	3,9	5-7	10-12,19
5	Convection	7	4		3
6	Radiation-Introduction	8-10	5,10	8	4,5
7	Rate of Cooling - Part 1	11	6,11	9,10	
8	Rate of Cooling - Part 2	12	12	11-13	6,7, 13-15,20
9	Wien's displacement law	13,14	7	14-16	8,16,17
10	After complete chapter	15,16			9

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Conduction-Introduction

Q1. Which of the following cylindrical rods will conduct most heat, when their ends are maintained at the same steady temperature:-

(A) length 1 m; radius 1 cm

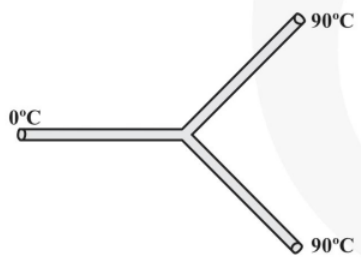
(B) length 2 m; radius 1 cm

(C) length 2 m; radius 2 cm

(D) length 1 m; radius 2 cm

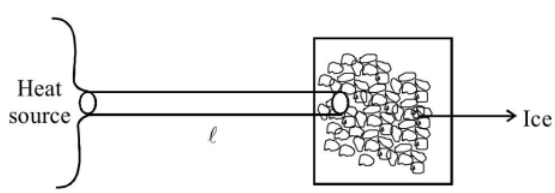
Thermal Resistance and Junction Rule

Q2. Three rods made of the same material and having the same cross–section have been joined as shown in the figure. Each rod is of the same length. The left and right ends are kept at 0°C and 90°C respectively. The temperature of junction of the three rods will be :

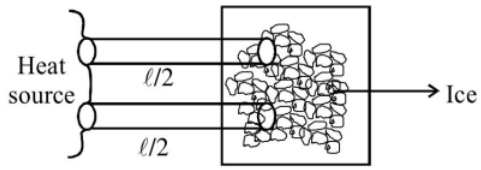


(A) 45°C (B) 60°C (C) 30°C (D) 20°C

Q3. A rod of length 'ℓ' and cross-section 'A' is used to melt a piece of ice as shown.



Now if the rod broken into two equal parts and is arranged as shown.

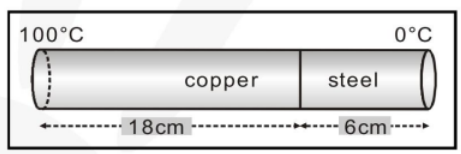


Time taken to melt ice in second use becomes.

(A) Half (B) One-fourth

(C) Twice (D) Four times

Q4. The coefficient of thermal conductivity of copper is nine times that of steel. In the composite cylindrical bar shown in the figure what will be the temperature at the junction of copper and steel ?



(A) 75°C (B) 67°C

(C) 33°C (D) 25°C

Conduction-Miscelleneous

Q5. **Statement–1 :** The bulb of one thermometer is spherical while that of the other is cylindrical. Both have equal amount of mercury. The response of the cylindrical bulb thermometer will be quicker.

Statement–2 : Heat conduction in a body is directly proportional to cross–sectional area.

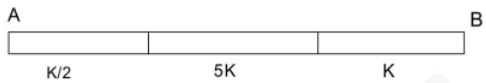
(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is True; Statement–2 is not a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Q6. A composite rod made of three rods of equal length and cross-section as shown in the fig. The thermal conductivities of the materials of the rods are K/2, 5K and K respectively. The end A and end B are at constant temperatures. All heat entering the end A goes out of the end B, there being no loss of heat from the sides of the bar. The effective thermal conductivity of the bar is



(A) 15K/16 (B) 6K/13
(C) 5K/16 (D) 2K/13

Convection

Q7. In which of the following process, convection does not take place primarily :-
(A) Sea and land breeze
(B) Boiling of water
(C) Warming of glass of bulb due to filament
(D) Heating air around a furnace

Radiation-Introduction

Q8. The rectangular surface of area 8cm × 4 cm of a black body at a temperature of 127°C emits energy at the rate of E per second. If the length and breadth of the surface are each reduced to half of the initial value and the temperature is raised to 327°C, the rate of emission of energy will become.

(A) $\frac{3}{8}E$ (B) $\frac{81}{16}E$
(C) $\frac{9}{16}E$ (D) $\frac{81}{64}E$

Q9. The rate of emission of radiation of a black body at 273°C is E, then the rate of emission of radiation of this body at 0°C will be :-

(A) $\frac{E}{16}$ (B) $\frac{E}{4}$ (C) $\frac{E}{8}$ (D) 0

Q10. Two spheres of the same material have radii 1 m and 4 m and temperatures 4000 K and 2000 K respectively. The ratio of the energy radiated per second by the first sphere to that by the second is-
(A) 1 : 1 (B) 16 : 1 (C) 4 : 1 (D) 1 : 9

Rate of Cooling - Part 1

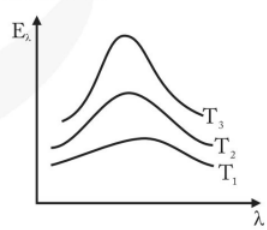
Q11. A black body calorimeter filled with hot water cools from 60°C to 50°C in 4 min and 40°C to 30°C in 8 min. The approximate temperature of surrounding is :
(A) 10°C (B) 15°C (C) 20°C (D) 25°C

Rate of Cooling - Part 2

Q12. A system S receives heat continuously from an electrical heater of power 10W. The temperature of S becomes constant at 50°C when the surrounding temperature is 20°C. After the heater is switched off, S cools from 35.1°C to 34.9°C in 1 minute. The heat capacity of S is
(A) 100J/°C (B) 300J/°C
(C) 750J/°C (D) 1500J/°C

Wien's displacement law

Q13. Variation of radiant energy emitted by sun, filament of tungsten lamp and welding arc as a function of its wavelength is shown in figure. Which of the following option is the correct match :



(A) Sun–T_1, tungsten filament–T_2, welding arc–T_3
(B) Sun–T_2, tungsten filament–T_1, welding arc–T_3
(C) Sun–T_3, tungsten filament–T_2, welding arc–T_1
(D) Sun–T_3, tungsten filament–T_1, welding arc–T_2

Q14. The Wien's displacement law express relation between :-

(A) wavelength corresponding to maximum energy and temperature

(B) radiation energy and wavelength

(C) temperature and wavelength

(D) colour of light and temperature

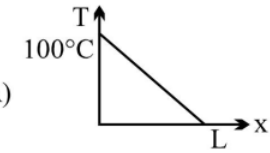
After Full Chapter

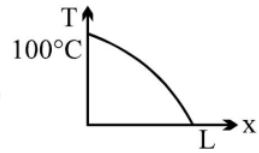
Q15. The dimensional formula for thermal resistance is :-

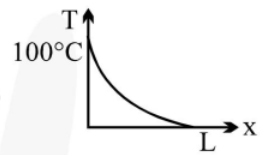
(A) $M^{-1}L^{-2}T^{3}\theta$ (B) $M^{-1}L^{-2}T^{-3}\theta$

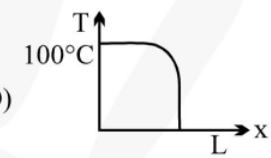
(C) $ML^{2}T^{-2}\theta$ (D) $ML^{2}T^{2}\theta^{-1}$

Q16. A rod of length L and uniform cross-sectional area has varying thermal conductivity which changes linearly from 2K at end A to K at the other end B. The ends A and B of the rod are maintained at constant temperature 100°C and 0°C, respectively. At steady state, the graph of temperature : T = T(x) where x = distance from end A will be

(A)


(B)


(C)


(D)


Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. On a cold morning, a metal surface will feel colder to touch than a wooden surface because :-

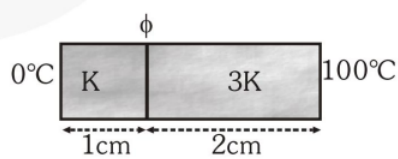
(A) metal has high specific heat

(B) metal has high thermal conductivity

(C) metal has low specific heat

(D) metal has low thermal conductivity

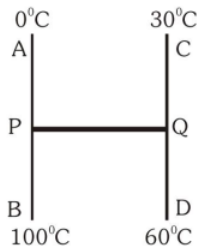
Q2. Two bars of thermal conductivities K and 3K and lengths 1 cm and 2 cm respectively have equal cross-sectional area. They are joined lengths wise as shown in the figure. If the temperature at the ends of this composite bar is 0°C and 100°C respectively (see figure), then the temperature of the interface (ϕ) is :–



(A) 50°C (B) $\frac{100}{3}$°C

(C) 60° C (D) $\frac{200}{3}$ °C

Q3. Three identical rods AB, CD and PQ are joined as shown. P and Q are mid points of AB and CD respectively. Ends A, B, C and D are maintained at 0^0C, 100^0C, 30^0C and 60^0C respectively. The direction of heat flow in PQ is :-



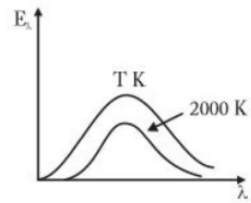
(A) From P to Q
(B) From Q to P
(C) Heat does not flow in PQ
(D) Data not sufficient

Q4. While measuring the thermal conductivity of a liquid, we keep the upper part hot and the lower part cool so that :–
(A) convection may be stopped
(B) radiation may be stopped
(C) heat conduction is easier downwords
(D) it is easier and convenient to do so

Q5. If the absorption coefficient and reflection coefficient of a surface of a body are 0.4 and 0.6 respectively then:–
(A) Emissive power will be 0.2
(B) Transmission power will be 0.2
(C) Body will be totally transparent
(D) Body will be totally opaque

Q6. According to Newton's law of cooling the rate of cooling of a body is proportional to:-
(A) temperature of the body
(B) temperature of the surrounding
(C) fourth power of the temperature of body
(D) difference of the temp. of the body and the surrounding.

Q7. The adjoining diagram shows the spectral energy density distribution E_λ of a black body at two different temperatures. If area under the curves are in the ratio 16:1, the value of temp T is:

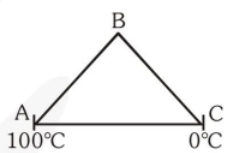


(A) 2000 K (B) 4000 K
(C) 8000 K (D) 6000 K

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q8. Three rods of equal length of same material are joined to form an equilateral triangle ABC as shown in figure. Area of cross–section of rod AB is S, of rod BC is 2S and that of AC is S, then



Column I	Column II
(A) Temperature of junction B	(P) Greater than 50°C
(B) Heat current in AB	(Q) Less than 50°C
(C) Heat current in BC	(R) Is equal to heat current in BC
	(S) Is $\frac{2}{3}$ times heat current in AC
	(T) None

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q9. A wall has two layer A and B each made of different material, both the layers have the same thickness. The thermal conductivity of the material A is twice that of B. Under thermal equilibrium the temperature difference across the wall B is 36°C. The temperature difference across the wall A is-

SUBJECTIVE TYPE

Q10. Two spherical ideal black bodies of radii r_1 and r_2 and with surface temperature T_1 and T_2 respectively, If both radiate the same power. Then calculate the ratio of $\frac{T_1}{T_2}$ is.

Q11. One end of a 2.35m long and 2.0cm radius aluminium rod ($K = 235\ W.m^{-1}K^{-1}$) is held at 20^0C. The other end of the rod is in contact with a block of ice at its melting point. The rate in $kg.s^{-1}$ at which ice melts is

[Take latent heat of fusion for ice as $\frac{10}{3}\times10^5\ J.kg^{-1}$]

Q12. Cooling rate of a sphere of 600 K at external environment (200 K) is R when the temperature of sphere is reduced to 400 K than cooling rate of the sphere is.

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. In which process, the rate of transfer of heat is maximum :–

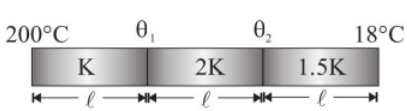
(A) conduction

(B) convection

(C) radiation

(D) in all these, heat is transferred with the same velocity

Q2. Calculate $(\theta_1+\theta_2)$ in shown situation.



(A) 150°C (B) 120°C

(C) 100°C (D) 190°C

Q3. Two walls of thicknesses d_1 and d_2 and thermal conductivity K_1 and K_2 are in contact. In the steady state, if the temperatures at the outer surface are T_1 and T_2, the temperature at the common wall is-

(A) $\frac{K_1T_1d_2+K_2T_2d_1}{K_1d_2+K_2d_1}$

(B) $\frac{K_1T_1+K_2T_2}{d_1+d_2}$

(C) $\left(\frac{K_1d_1+K_2d_2}{T_1+T_2}\right)T_1T_2$

(D) $\frac{K_1d_1T_1+K_2d_2T_2}{K_1d_1+K_2d_2}$

Q4. Two Plates of equal areas are placed in contact with each other. Their thickness are 2cm and 3cm respectively. Temperature of external surface of first plate is –25° C and that of external surface of second plate is 25° C What will be temperature of contact surface if the plates :-

(i) Are of same material

(ii) Have thermal Conductivity in ratio 2 : 3.

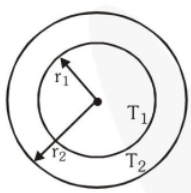
(A) (i) –5°C (ii) 0°C

(B) (i) 5°C (ii) 0°C

(C) (i) 0°C (ii) –5°C

(D) None of these

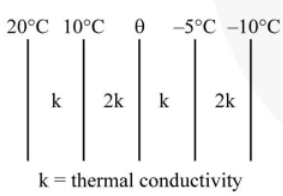
Q5. The figure shows a system of two concentric spheres of radii r_1 and r_2 and kept at temperatures T_1 and T_2, respectively. The radial rate of flow of heat in a substance between the two concentric spheres, is proportional to :-



(A) $\frac{(r_2 - r_1)}{(r_1 r_2)}$ (B) $\ell n\left(\frac{r_2}{r_1}\right)$

(C) $\frac{r_1 r_2}{(r_2 - r_{1)}}$ (D) $(r_2 - r_1)$

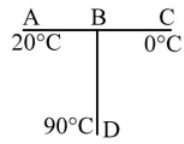
Q6. The figure shows the face and interface temperature of a composite slab containing of four layers of two materials having identical thickness. Under steady state condition, find the value of temperature θ.



(A) 5°C (B) 10°C

(C) –15°C (D) 15°C

Q7. Three conducting rods of same material and cross-section are shown in figure. Temperature of A, D and C are maintained at 20°C, 90°C and 0°C. Find the ratio of length BD and BC if there is no heat flow in AB



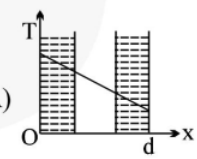
(A) $\frac{7}{2}$ (B) $\frac{3}{2}$ (C) $\frac{9}{2}$ (D) $\frac{5}{2}$

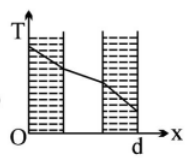
Q8. The power radiated by a black body is P and it radiates maximum energy around the wavelength λ_0. If the temperature of the black body is now changed so that it radiates maximum energy around wavelength $3/4\lambda_0$, the power radiated by it will increase by a factor of :-

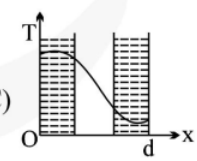
(A) 4/3 (B) 16/9

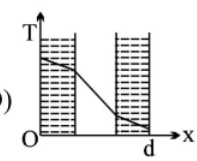
(C) 64/27 (D) 256/81

Q9. The wall with a cavity consists of two layers of brick separated by a layer of air. All three layers have the same thickness and the thermal conductivity of the brick is much greater than that of air. The left layer is at a higher temperature than the right layer and steady state condition exists. Which of the following graphs predicts correctly the variation of temperature T with distance d inside the cavity?

(A) 

(B) 

(C) 

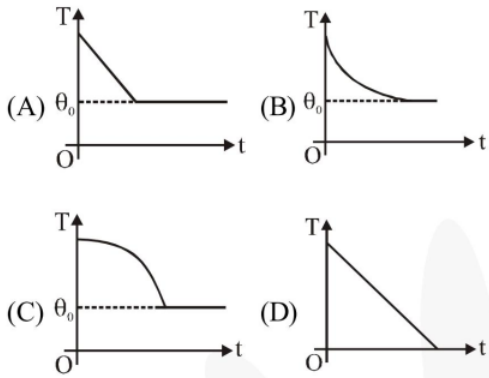
(D) 

Q10. Water of volume 2L in a container is heated with a coil of 1 kW at 27°C. The lid of the container is open and energy dissipates at rate of 160 J/s. In how much time temperature will rise from 27°C to 77°C ? (Give specific heat of water is 4.2 kJ/kg) :-

(A) 8 min 20 s (B) 6 min 2 s

(C) 7 min (D) 14 min

Q11. If a piece of metal is heated to temperature θ and then allowed to cool in a room which is at temperature θ_0, the graph between the temperature T of the metal and time t will be closest to :



Q12. Spheres P and Q are uniformly constructed from the same material which is a good conductor of heat and the radius of Q is thrice the radius of P. The rate of fall of temperature of P is x times that of Q when both are at the same surface temperature? The value of x is :

(A) 1/4 (B) 1/3

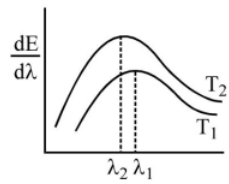
(C) 3 (D) 4

Q13. A system S receives heat continuously from an electrical heater of power 10W. The temperature of S becomes constant at 50°C when the surrounding temperature is 20°C. After the heater is switched off, S cools from 35.1°C to 34.9°C in 1 minute. The heat capacity of S is:–

(A) 100 J/°C (B) 300 J/°C

(C) 750 J/°C (D) 1500 J/°C

Q14. The spectral emissive power E_λ for a body at temperature T_1 is plotted against the wavelength and area under the curve is found to be A. At a different temperature T_2 the area is found to be 9A. Then λ_1/λ_2 =



(A) 3 (B) 1/3

(C) $1/\sqrt{3}$ (D) $\sqrt{3}$

Q15. A black body is at a temperature of 2880 K. The energy of radiation emitted by this object with wavelength between 499 nm and 500 nm is U_1, between 999 nm and 1000 nm is U_2 and between 1499 nm and 1500 nm is U_3. The Wien constant $b = 2.88 \times 10^6$ nm K. Then -

(A) $U_1 = 0$ (B) $U_3 = 0$

(C) $U_1 > U_2$ (D) $U_2 > U_1$

Q16. Three discs A, B, and C having radii 2 m, 4 m and 6 m respectively are coated with carbon black on their outer surfaces. The wavelengths corresponding to maximum intensity are 300 nm, 400 nm and 500 nm respectively. The power radiated by them are Q_A, Q_B and Q_C respectively.

(A) Q_A is maximum

(B) Q_B is maximum

(C) Q_C is maximum

(D) $Q_A = Q_B = Q_C$

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. In a 10–metre–deep lake, the bottom is at a constant temperature of 4°C. The air temperature is constant at –4°C. The thermal conductivity of ice is 3 times that of water. Neglecting the expansion of water on freezing, the maximum thickness of ice will be :-

(A) 7.5 m (B) 6 m

(C) 5 m (D) 2.5 m

Q2. The heat of flowing through a rod of length 50 cm and area of cross-section 5 cm^2. Its ends are respectively at 25°C and 125°C. The coefficient of thermal conductivity of the material of the rod is 0.092 kcal/m × s × C. The temperature gradient in the rod is :-

(A) 2°C/cm

(B) 0.2°C/m

(C) 2°C/m

(D) 20°C/m

Q3. It is hotter for the same distance over the top of a fire than it is in the side of it, mainly because :–

(A) air conducts heat upwards

(B) heat is radiated upwards

(C) convection takes more heat upwards

(D) convection, conduction and radiation all contribute significantly transferring heat upward

Q4. The emissive power of a black body at T = 300 K is 100 Watt/m^2. Consider a body B of area A = 10 m^2, coefficient of reflectivity r = 0.3 and coefficient of transmission t = 0.5. Its temperature is 300 K. Then which of the following is incorrect:–

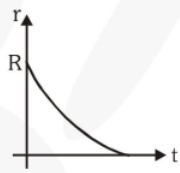
(A) The emissive power of B is 20 W/m^2

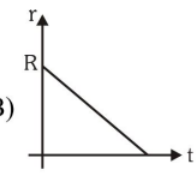
(B) The emissive power of B is 200 W/m^2

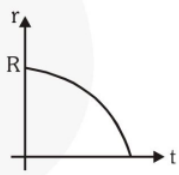
(C) The power emitted by B is 200 Watt

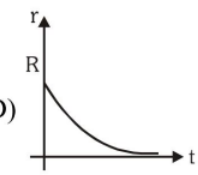
(D) The emissivity of B is = 0.2

Q5. A sphere of ice at 0^0C having initial radius R is placed in an environment having ambient temperature > 0^0C. The ice melts uniformly, such that shape remains spherical. After a time 't' the radius of the sphere has reduced to r. Which graph best depicts r(t)

(A) 

(B) 

(C) 

(D) 

Q6. A hollow copper sphere & a hollow copper cube of same surface area & negligible thickness, are filled with warm water of same temperature and placed in an enclosure of constant temperature, a few degrees below that of the bodies. Then in the beginning :-

(A) The rate of energy lost by the sphere is greater than that by the cube

(B) The rate of energy lost by the two are equal

(C) The rate of energy lost by the sphere is less than that by the cube

(D) The rate of fall of temperature for sphere is less than that for the cube.

Q7. 'Gulab Jamuns' (assumed to be spherical) are to be heated in an oven. They are available in two sizes, one twice bigger (in radius) than the other. Pizzas (assumed to be discs) are also to be heated in oven. They are also in two sizes, one twice big (in radius) than the other. All four are put together to be heated to oven temperature. Choose the correct option from the following:

(A) Both size gulab jamuns will get heated in the same time.

(B) Smaller gulab jamuns are heated before bigger ones.

(C) Smaller pizzas are heated before bigger ones.

(D) Bigger pizzas are heated before smaller ones.

Q8. An ideal black–body at room temperature is thrown into a furnance. It is observed that

(A) initially it is the darkest body and at later times the brightest

(B) it is the darkest body at all times

(C) it cannot be distinguished at all times

(D) initially it is the darkest body and at later times it cannot be distinguished

Q9. A long solid cylinder is radiating power. It is remoulded into a number of smaller cylinders, each of which has the same length as original cylinder. Each small cylinder has the same temperature as the original cylinder. The total radiant power emitted by the pieces is twice that emitted by the original cylinder. How many smaller cylinders are there ? Neglect the energy emitted by the flat faces of cylinder.

(A) 3 (B) 4

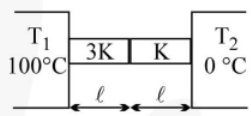
(C) 5 (D) 6

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 10 to 12

Two rods A and B of same cross-sectional are A and length l connected in series between a source (T_1 = 100°C) and a sink (T_2 = 0°C) as shown in figure. The rod is laterally insulated.



Q10. The ratio of the thermal resistance of the rods is -

(A) $\frac{R_A}{R_B} = \frac{1}{3}$ (B) $\frac{R_A}{R_B} = 3$

(C) $\frac{R_A}{R_B} = \frac{3}{4}$ (D) $\frac{4}{3}$

Q11. If T_A and T_B are the temperature drops across the rod A and B, then -

(A) $\frac{T_A}{T_B} = \frac{3}{1}$ (B) $\frac{T_A}{T_B} = \frac{1}{3}$

(C) $\frac{T_A}{T_B} = \frac{3}{4}$ (D) $\frac{T_A}{T_B} = \frac{4}{3}$

Q12. If G_A and G_B are the temperature gradients across the rod A and B, then -

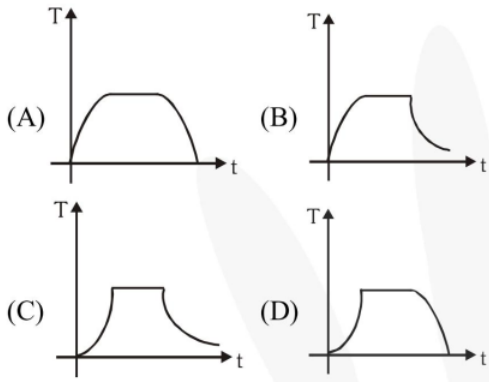
(A) $\frac{G_A}{G_B} = \frac{3}{1}$ (B) $\frac{G_A}{G_B} = \frac{1}{3}$

(C) $\frac{G_A}{G_B} = \frac{3}{4}$ (D) $\frac{G_A}{G_B} = \frac{4}{3}$

Paragraph for Question No. 13 to 15

In a home experiment, Ram brings a new electric kettle with unknown power rating. He puts 1 litre water in the kettle and switches on. But to his dismay, the temperature becomes constants at 60^0C after some time. The room temperature is 20^0C. Ram gets bored and switches off the kettle. He sees that during first 20 s water cools down by 2^0C.

Q13. Which is the best graph for temperature v/s time?



Q14. What is the wattage of the kettle

(A) 840W (B) 1W

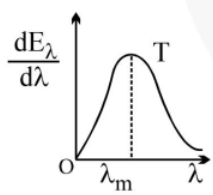
(C) 100W (D) 420 W

Q15. What is the time taken for the water to cool to 40^0C. (Approx)

(A) 510 s (B) 270 s (C) 120 s (D) 410 s

Paragraph for Question No. 16 to 17

The figure shows a radiant energy spectrum graph for a black body at a temperature T.



Q16. Choose the **CORRECT** statement(s)

(A) The radiant energy is not equally distributed among all the possible wavelengths.

(B) For a particular wavelength the spectral intensity is maximum.

(C) The area under the curve is equal to the total rate at which heat is radiated by the body at that temperature.

(D) None of these

Q17. If the temperature of the body is raised to a higher temperature T', then choose the correct statement(s)

(A) The intensity of radiation for every wavelength increases

(B) The maximum intensity occurs at a shorter wavelength

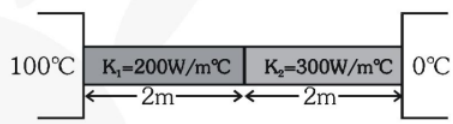
(C) The area under the graph increases

(D) The area under the graph is proportional to the fourth power of temperature

NUMERICAL TYPE

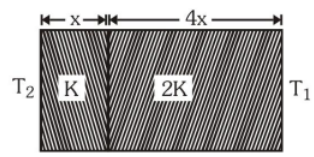
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q18. For shown situation, calculate the temperature of the interface.



SUBJECTIVE TYPE

Q19. The temperature of the two outer surfaces of a composite slab, consisting of two materials having coefficients of thermal conductivity K and 2K and thickness x and 4x, respectively are T_2 and T_1 ($T_2 > T_1$). The rate of heat transfer through the slab, in a steady state is $\left(\frac{A(T_2 - T_1)K}{x}\right)$ f, with f equals to-



Q20. If a liquid takes 30 sec. in cooling of 80°C to 70°C and 70 sec in cooling 60°C to 50°C, then find the room temperature.

Answer Key

Ex-1									
1	2	3	4	5	6	7	8	9	10
D	B	B	A	A	A	C	D	A	A
11	12	13	14	15	16				
B	D	D	A	A	B				

Ex-1A

1. B **2.** C **3.** A **4.** A **5.** D

6. D **7.** B **8.** (A)-P; (B)-R; (C)-T **9.** 18°C

10. $\sqrt{\frac{r_2}{r_1}}$ **11.** $2.4\pi \times 10^{-6}$ **12.** $\frac{3}{16}$ R

Ex-2									
1	2	3	4	5	6	7	8	9	10
C	D	A	A	C	A	A	D	D	A
11	12	13	14	15	16				
B	C	D	D	D	B				

Ex-2A

1. A **2.** A **3.** C **4.** A **5.** B

6. B,D **7.** B **8.** D **9.** B **10.** A

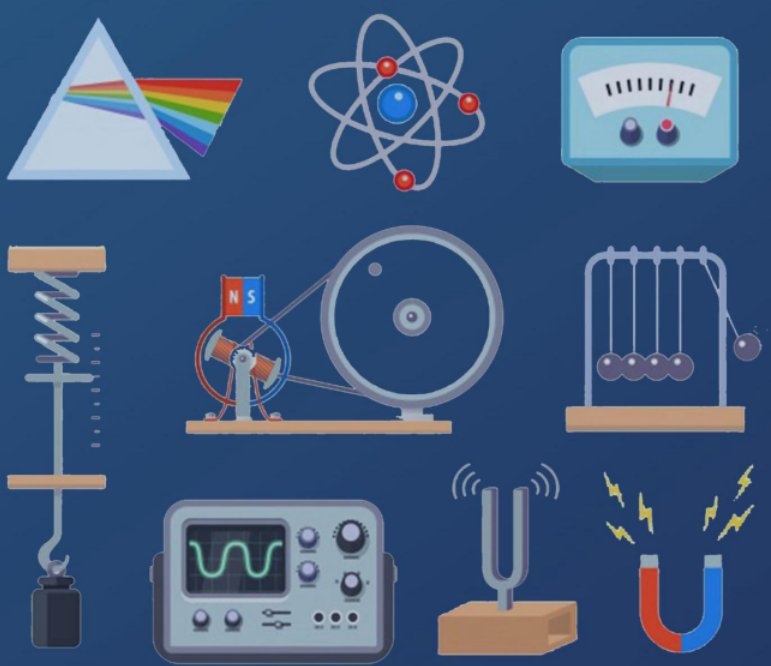
11. B **12.** B **13.** B **14.** D **15.** B

16. A,B **17.** A,B,C,D **18.** 40°C **19.** 1/3 **20.** 40°C

-: Important Notes & Formulas :-

PHYSICS

Kinematics 1D



SHEET

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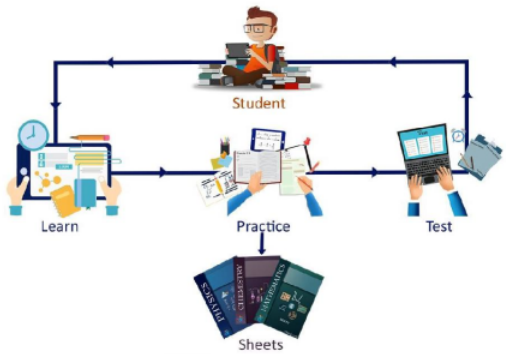
7.	Answer Key	Page - 15

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr. No.	Topic	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Distance and Displacement	1, 2, 4			
2	Differentiation	5, 6, 7, 8, 9	1	2, 3, 4	
3	Speed, Velocity and Acceleration	3, 10-12	2, 3, 5	1, 5, 6	1
4	Motion Under Constant Acceleration-Part1	14	6, 18	8	
5	Motion Under Constant Acceleration-Part2	13, 15	12, 16, 17	7, 9, 10	12
6	Motion Under Gravity-Part1	16, 18	15		
7	Motion Under Gravity-Part2	17, 19	4, 7, 21	11, 12, 15, 16, 13, 14	11, 13
8	Relative Motion-Part1	20, 21, 22	19		
9	Relative Motion-Part2	23		17	15
10	Graphical Interpretation of Differentiation-Part1	24, 25, 26, 27	8, 9	18, 19	
11	Graphical Interpretation of Differentiation-Part2	28, 29, 30	10, 13		
12	Graphs	31, 33, 34			2
13	Conversion of Graphs	32	11, 14		3
14	Integration-Part1	36, 37	20	20	
15	Integration-Part2	35		21	5, 14
16	Integration-Part3	38		21	4, 6, 7, 8, 9, 10

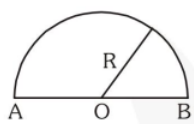
Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Distance and Displacement

Q1. A particle moves from A to B in a semicircle. Then the ratio of distance to displacement is :-



(A) $\frac{\pi}{2}$ (B) $\frac{2}{\pi}$

(C) $\frac{\pi}{4}$ (D) 1 : 1

Q2. A table clock has minute hand 4 cm long. The displacement of tip of minute hand between 6:00 pm to 6:15 pm is :-

(A) 4 cm (B) πcm

(C) $4\sqrt{2}$ cm (D) 8 cm

Q3. A man walks 5m north then 4m east then $5\sqrt{2}$ m south-west. The displacement from initial to final position is :-

(A) 1 m West

(B) 1m East

(C) $10\sqrt{2}$ m North-east

(D) None of above

Rate of Change Or Differentiation

Q4. $\frac{d}{dx}\left(\frac{1}{x^7}\right)$ is -

(A) $-7x^{-6}$ (B) $-7x^{-8}$

(C) $7x^{-6}$ (D) $7x^{-8}$

Q5. If $v = t^2 - 4t + 5$ then $\frac{dv}{dt}$ is -

(A) $2t - 4$ (B) $t - 4$

(C) $2t^2 + 5$ (D) Zero

Q6. $\frac{d}{d\theta}(\sin 2\theta)$ is

(A) $2\cos 2\theta$ (B) $\frac{1}{2}\cos 2\theta$

(C) $-2\cos 2\theta$ (D) $-\frac{1}{2}\cos 2\theta$

Q7. The value of $\frac{d}{dx}\left(\frac{x}{\sin x}\right)$ will be :-

(A) $\frac{\sin x - x\cos x}{\sin^2 x}$ (B) $\frac{\cos x - x\sin x}{\sin^2 x}$

(C) $\frac{x\cos x - \sin x}{\cos^2 x}$ (D) $\frac{x\sin x - \cos x}{\cos^2 x}$

Q8. $\frac{d}{dx}\left(e^{\sin\frac{\pi}{4}}\right)$ is -

(A) $e^{\cos\frac{\pi}{4}}$ (B) $\frac{\pi}{4}e^{\sin\frac{\pi}{4}}$

(C) $\frac{\pi}{4}e^{\sin\frac{\pi}{4}}\cos\frac{\pi}{4}$ (D) Zero

Speed, Velocity and Acceleration

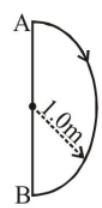
Q9. In 1.0 sec. a particle goes from point A to point B moving in a semicircle of radius 1.0 m. The magnitude of average velocity is:-

(A) 3.14 m/sec

(B) 2.0 m/sec

(C) 1.0 m/sec

(D) zero



Q10. A particle moves along x-axis in such a way that its co-ordinate x varies with time t according to the equation $x = (2 - 5t + 6t^2)$ m. The initial velocity of the particle is :

(A) – 5 m/s (B) 6 m/s

(C) – 3 m/s (D) 3 m/s

Q11. The displacement x of a particle along a straight line at time t is given by

$x = a_0 + a_1t + a_2t^2$.

The acceleration of the particle is:

(A) a_0 (B) a_1

(C) $2a_2$ (D) a_2

Q12. The velocity of a particle moving on the x-axis is given by $v = x^2 + x$ where v is in m/s and x is in m. Find its acceleration in m/s^2 when passing through the point x = 2m.

(A) 0 (B) 5

(C) 11 (D) 30

Motion Under Constant Acceleration

Q13. A car starts from rest travelling with constant acceleration. If distance covered by it in 10th second of its journey is 19m, what will be the acceleration of car :-

(A) $4\ m/s^2$ (B) $3\ m/s^2$

(C) $2\ m/s^2$ (D) $1\ m/s^2$

Q14. A body starts from rest and is uniformly accelerated for 30 s. The distance travelled in the first 10 s is x_1, next 10 s is x_2 and the last 10 s is x_3. Then $x_1 : x_2 : x_3$ is the same as:-

(A) 1 : 2 : 4 (B) 1 : 2 : 5

(C) 1 : 3 : 5 (D) 1 : 3 : 9

Q15. A car moving with a speed of 12 m/s can be stopped by applying brakes after travelling a distance of 6m. If the same car is moving with a speed of 24 m/s then the stopping distance of the car is :

(A) 24 m (B) 12 m

(C) 18 m (D) 30 m

Motion Under Gravity part

Q16. A ball is projected upwards. Its acceleration at the highest point is :-

(A) zero

(B) directed upward

(C) directed downwards

(D) such as cannot be predicted

Q17. A body is thrown upward and reaches its maximum height. At that position-

(A) Its velocity is zero and its acceleration is also zero.

(B) Its velocity is zero but its acceleration is maximum.

(C) Its acceleration is minimum.

(D) Its velocity is zero and its acceleration is acceleration due to gravity.

Q18. A stone dropped from the top of the tower touches the ground in 4 sec. The height of the tower is about :-

(A) 80 m (B) 40 m

(C) 20 m (D) 160 m

Q19. With what speed should a body be thrown upwards so that the distances traversed in 5th second and 6th second are equal ?

(Take $g = 9.8\ m/s^2$)

(A) 58.4 m/s (B) 49 m/s

(C) $\sqrt{98}$ m/s (D) 98 m/s

Relative Motion

Q20. Two cars are moving towards each other with velocity 4m/s & 8 m/s respectively from two different points in straight line, 1200 m apart simultaneously, find time after which both cars meet :-

(A) 300 sec

(B) 150 sec

(C) 100 sec

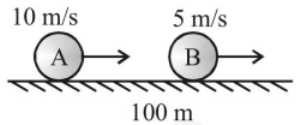
(D) None of these

Q21. Two cars A & B start from rest (from the same point) in same direction with acceleration 8 m/s² & 4 m/s² respectively then acceleration of car B in frame of A (Take direction of motion of car is positive):-

(A) 4 m/s² (B) – 4 m/s²

(C) 12 m/s² (D) None of these

Q22. An object A is moving with 10 m/s and B is moving with 5 m/s in the same direction of positive x- axis. A is 100 m behind B as shown. Find time taken by A to meet B :-



(A) 18 sec (B) 16 sec

(C) 20 sec (D) 17 sec

Q23. If a lift is moving downwards with constant velocity 5 m/s. A coin is dropped from the lift, find velocity of coin at the same instant when it is dropped in frame of lift and in frame of ground :-

(A) 5 m/s (downward) & 0

(B) 0 & 5 m/s (downward)

(C) 5 m/s (upward) & 0

(D) 0 & 5 m/s (upward)

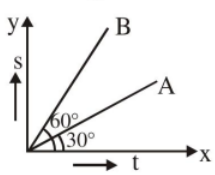
Graphical Interpretation of Differentiation

Q24. Slope of tangent to velocity time curve is :-

(A) Distance (B) Speed

(C) Acceleration (D) None of above

Q25. The displacement-time graphs of two bodies A and B are shown in figure. The ratio of velocity of A, v_A to velocity of B, v_B is :-



(A) $\frac{1}{\sqrt{3}}$ (B) $\sqrt{3}$ (C) $\frac{1}{3}$ (D) 3

Q26. The slope of the velocity-time graph for retarded motion is :-

(A) zero

(B) positive

(C) negative

(D) positive or negative

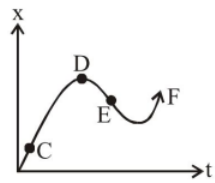
Q27. The displacement–time graph of a moving particle is shown below. The instantaneous velocity of the particle is negative at the point.

(A) C

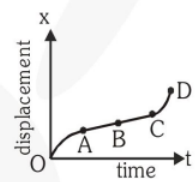
(B) D

(C) E

(D) F

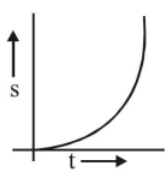


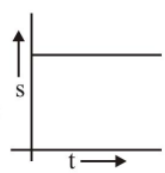
Q28. The graph between the displacement x and time t for a particle moving in a straight line is shown in figure. During the interval OA, AB, BC and CD, the acceleration of the particle is :

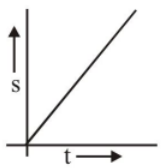


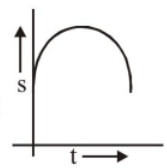
	OA,	AB,	BC,	CD
(A)	+	0	+	+
(B)	–	0	+	0
(C)	+	0	–	+
(D)	–	0	0	+

Q29. A body is travelling in a straight line with a uniformly increasing speed. Which one of the plot represents the distance (s) travelled with time (t) ?

(A) 

(B) 

(C) 

(D) 

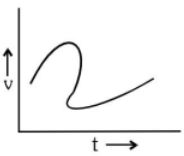
Q30. If $y = x^3 - 12x + 4$ then condition for maximum y is -

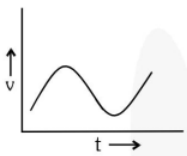
(A) $x = 2$ (B) $x = -2$

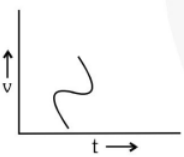
(C) $x = \pm 2$ (D) $x = 4$

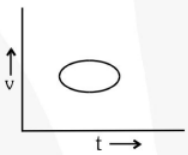
Graphs

Q31. Which of the following velocity–time graph shows a realistic situation for a body in motion :–

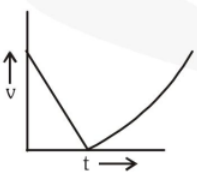
(A) 

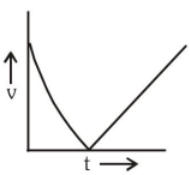
(B) 

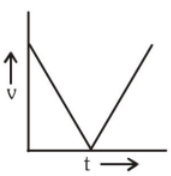
(C) 

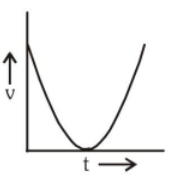
(D) 

Q32. A ball is thrown vertically upwards. Which of the following plots represents the speed–time graph of the ball during its flight if air resistance is ignored :–

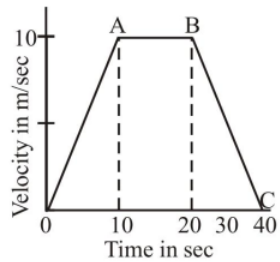
(A) 

(B) 

(C) 

(D) 

Q33. The adjoining curve represents the velocity–time graph of a particle, its acceleration values along OA, AB and BC in metre/sec^2 are respectively :-

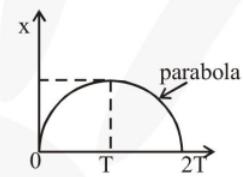


(A) 1, 0, –0.5 (B) 1, 0, 0.5

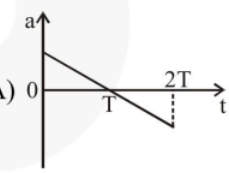
(C) 1, 1, 0.5 (D) 1, 0.5, 0

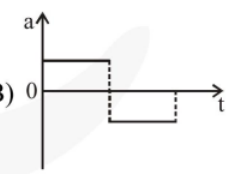
Conversion of Graphs

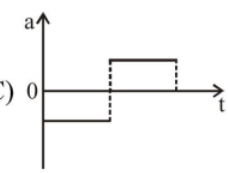
Q34. The x–t graph of a particle moving along a straight line is shown in figure.

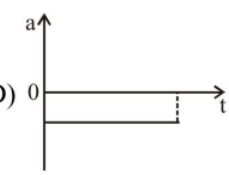


The a–t graph of the particle is correctly shown by :-

(A) 

(B) 

(C) 

(D) 

Integration

Q35. The value of $\int \frac{1}{x^3}\,dx$ is -

(A) $-3x^{-4}+c$ (B) $\frac{x^{-4}}{-4}+c$

(C) $\frac{x^{-2}}{-2}+c$ (D) $-2x^{-2}+c$

Q36. The value of $\int_0^1 (x^2-4x+5)\,dx$ is :-

(A) $\frac{5}{3}$ (B) $\frac{10}{3}$

(C) $\frac{8}{3}$ (D) $\frac{11}{3}$

Q37. The area under acceleration-time graph gives:-

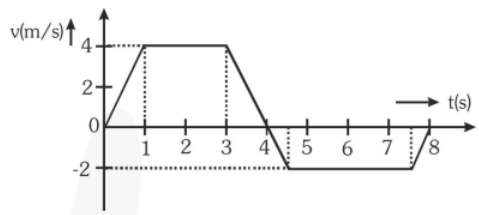
(A) Distance travelled

(B) Change in acceleration

(C) Force acting

(D) Change in velocity

Q38. The velocity – time graph of a linear motion is shown in figure. The displacement & distance from the origin after 8 sec. is :-



(A) 5 m, 19m (B) 16 m,22m

(C) 8 m,19m (D) 6 m, 5m

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Mark the correct options

if $x=\frac{1}{t^{3/8}}$, $y=t^{-4}$:-

(A) $\frac{dx}{dt}=-\frac{3}{8}t^{-5/8}$ (B) $\frac{dx}{dt}=-\frac{3}{8}t^{-11/8}$

(C) $\frac{dy}{dt}=\frac{4}{t^5}$ (D) $\frac{dy}{dt}=-4t^{-5}$

Q2. The position of a bike is given by $x = t^2$. Mark the correct option :-

(A) Average speed between 2 to 3 second is 5 m/s

(B) Average speed between 2 to 3 second is 4 m/s

(C) Average speed between 2 to 2.1 second is 4.1 m/s

(D) Average speed between 2 to 2.1 second is 4.01 m/s

Q3. The position vector of a particle is given as $\vec{r}=e^t\hat{i}+\log_e t\,\hat{j}$. Find $\vec{v}$ and $\vec{a}$ at $t = 2$sec.

(A) $\vec{v}=\left(e^2\hat{i}+\frac{1}{2}\hat{j}\right)m/s$

(B) $\vec{a}=\left(e^2\hat{i}-\frac{1}{4}\hat{j}\right)m/s^2$

(C) $\vec{v}=\left(e^2\hat{j}+1\hat{k}\right)m/s$

(D) $\vec{a}=\left(e^2\hat{i}+\frac{1}{4}\hat{j}\right)m/s^2$

Q4. Which of the following statements are true for a moving body ?

(A) If its speed changes, its velocity must change and it must have some acceleration.

(B) If its velocity changes, its speeds must change and it must have some acceleration.

(C) If its velocity changes, its speed may or may not change, and it must have some acceleration.

(D) If its speed changes but direction of motion does not change, its velocity may remain constant.

Q5. The numerical ratio of magnitude of average velocity to average speed can be :-

(A) equal to one

(B) less than one and greator than zero

(C) zero

(D) more than one

Q6. A train accelerates from rest for time t_1 at a constant acceleration α for distance x. Then it decelerates to rest at constant retardation β in time t_2 for distance y. Then -

(A) $\frac{x}{y}=\frac{\beta}{\alpha}$ (B) $\frac{\beta}{\alpha}=\frac{t_1}{t_2}$

(C) $\frac{x}{y}=\frac{t_1}{t_2}$ (D) $x = y$

Q7. An object may have :-

(A) Varying speed without having varying acceleration

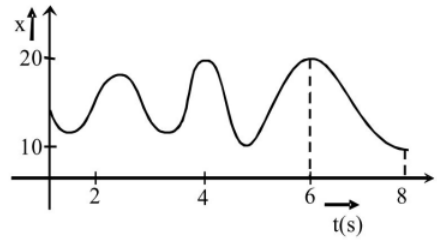
(B) Varying velocity without having varying speed

(C) Non–zero acceleration without having varying velocity

(D) Non–zero acceleration without having varying speed .

Q8. In the figure is shown the position of a particle moving on the x-axis as a function of time.

Then -



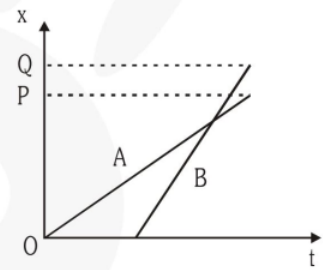
(A) the particle has come to rest for 6 times

(B) the maximum speed is at t = 6 s

(C) the velocity remain positive for t = 0 to t = 6s

(D) the average velocity for the total period shown is negative

Q9. The position–time (x–t) graphs for two children A and B returning from their school O to their homes P and Q respectively are shown in fig. They travel on same road. Choose the correct options:



(A) A lives closer to the school than B

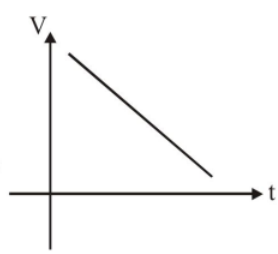
(B) B starts from the school earlier than A

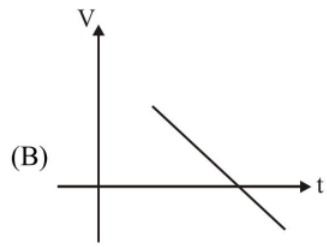
(C) B walks faster than A

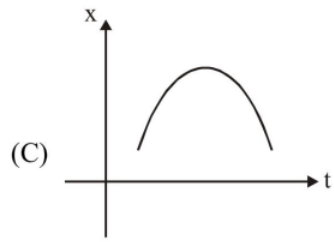
(D) B overtakes A on the road once.

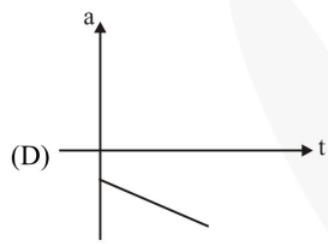
Q10. Mark correct option in which acceleration is negative :-

(A)

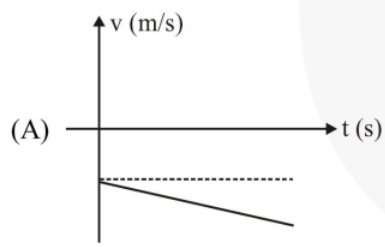


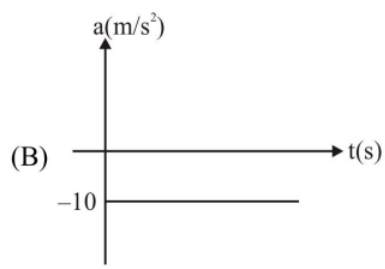


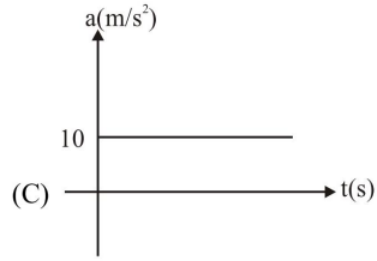


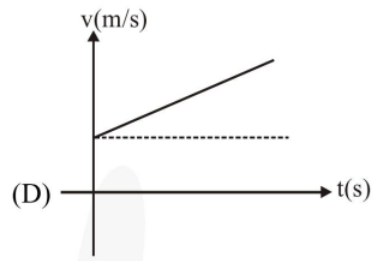


Q11. A particle is projected from top of a tower in vertical downward direction with velocity 10 m/s. Taking upward direction as +ve, choose plot a-t and v-t graph :-
[Take g = 10m/s^2]









MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

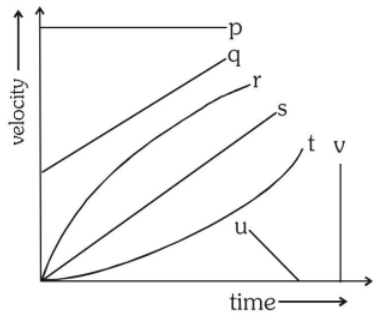
Q12. The equation of one dimensional motion of the particle is described in column I. At t = 0, particle is at origin and at rest. Match the column I with the statements in Column II.

Column I	**Column II**
(A) $x = (3t^2 + 2)$m	(p) Velocity of particle at t = 1 s is 8 m/s
(B) v = 8t m/s	(q) Particle moves with uniform acceleration
(C) a = 16t	(r) Particle moves with variable acceleration
(D) $v = 6t - 3t^2$	(s) Particle will change its direction some time.

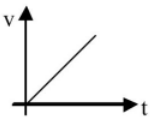
Q13. **Column I**

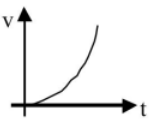
(A) Zero acceleration
(B) Infinite acceleration
(C) Constant positive acceleration, with zero initial velocity
(D) Constant positive acceleration, with non–zero initial velocity
(E) Constant Negative acceleration
(F) Increasing acceleration
(G) Decreasing acceleration

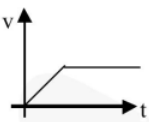
Column II

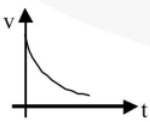


Q14. **Column I**

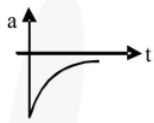
(A) 

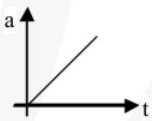
(B) 

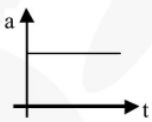
(C) 

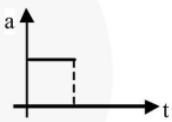
(D) 

Column II

(p) 

(q) 

(r) 

(s) 

ASSERTION AND REASON

Q15. **Statement I :** When velocity of a particle is zero then acceleration of particle is zero.

Statement II : Acceleration is equal to rate of change of velocity.

(A) Statement–I is true, Statement–II is true; Statement–II is correct explanation for Statement–I.
(B) Statement–I is true, Statement–II is true; Statement–II is NOT a correct explanation for statement–I.
(C) Statement–I is true, Statement–II is false.
(D) Statement–I is false, Statement–II is true.

Q16. **Statement I :** A particle moves in a straight line with constant acceleration. The average velocity of this particle cannot be zero in any time interval.

Statement II : For a particle moving in straight line with constant acceleration, the average velocity in a time interval is $\frac{u+v}{2}$, where u and v are initial and final velocity of the particle of the given time interval.

(A) Statement–I is true, Statement–II is true; Statement–II is correct explanation for Statement–I.
(B) Statement–I is true, Statement–II is true; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

Q17. **Statement–I :** A positive acceleration can be associated with a 'slowing down' of the body.

Statement–II : The origin and the positive direction of an axis are a matter of choice.

(A) Statement–I is true, Statement–II is true; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true; Statement–II is NOT a correct explanation for statement–I.

(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

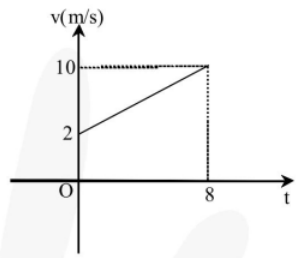
NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q18. A driver travelling at speed 36 kmh^{-1} sees the light turn red at the intersection. If his reaction time is 0.6s, and then the car can deaccelerate at $4ms^{-2}$. Find the stopping distance of the car.

Q19. Two cars travelling towards each other on a straight road at velocity 10 m/s and 12 m/s respectively. When they are 150 metre apart, both drivers apply their brakes and each car decelerates at 2 m/s^2 until it stops. How far apart will they be when they have both come to a stop ?

Q20. Figure shows the graph of velocity versus time for a particle going along x axis. Initially at t = 0, particle is at x = 3m. Find position of particle at t = 2s. (in m).



SUBJECTIVE TYPE

Q21. A ball is thrown vertically upwards with a velocity of 20 ms^{-1} from the top of a tower. The height of the tower is 25 m from the ground.

(i) How high will the ball rise from the top of the tower?

(ii) How long will it be before the ball hits the ground ? (Take g = 10 ms^{-2})

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. If $y = (x^2 + 4x - 5)^3$ then $\frac{dy}{dx}$ is :-

(A) $3\ (x^2 + 4x - 5)^2$

(B) $3\ (x^2 + 4x - 5)^4$

(C) $3\ (x^2 + 4x - 5)^3\ (2x + 4)$

(D) $3\ (x^2 + 4x - 5)^2\ (2x + 4)$

Q2. Temperature of a body varies with time as $T = T_0 + \alpha t^2 + \beta \sin t)$ where T_0 is the temperature in Kelvin at $t = 0$ sec. & $\alpha = 2/\pi$ K/s^2 & $\beta = -4$ K, then rate of change of temperature at $t = \pi$ sec. is-

(A) 8 K (B) 8K

(C) 8K/sec (D) 8K/sec

Q3. If $x = at^2$ & $y = bt^3$, then $\frac{dy}{dx} = ?$

(A) $\frac{3bt}{2a}$ (B) $\frac{2bt}{3a}$ (C) $\frac{2at}{3b}$ (D) $\frac{3b}{2a}$

Q4. A body has speed V, 2V and 3V for first 1/3rd of the distance S, second 1/3rd of S and third 1/3rd of S respectively. Its average speed will be :-

(A) V (B) 2V

(C) $\frac{18}{11}$V (D) $\frac{11}{18}$V

Q5. The velocity of a particle moving along x–axis is given as $v = x^2 - 5x + 4$ (in m/s) where x denotes the x–coordinate of the particle in metres. Find the magnitude of acceleration of the particle when the velocity of particle is zero ?

(A) 0 m/s^2 (B) 2 m/s^2

(C) 3 m/s^2 (D) None of these

Q6. The relation between time t and distance x is $t = \alpha x^2 + \beta x$ where α and β are constants. The retardation is :-

(A) $2\alpha v^3$ (B) $2\beta v^2$

(C) $2\alpha\beta v^2$ (D) $2\beta^2 v^3$

Q7. A particle is moving with uniform acceleration along a straight line. Its velocities at A & B are respectively 7 m/s & 17 m/s . M is mid point of AB . If t_1 is the time taken to go from A to M and t_2 the time taken to go from M to B, the ratio $\frac{t_1}{t_2}$ is equal to :-

(A) 3 : 2 (B) 3 : 1

(C) 2 : 1 (D) 2 : 3

Q8. A particle moves along a straight line OX. At a time t (in seconds) the distance x (in metres) of the particle from O is given by $x = 40 + 12t - t^3$. How much distance would the particle travel before coming to rest ?

(A) 24 m (B) 40 m

(C) 56 m (D) 16 m

Q9. A particle moves with uniform acceleration and v_1, v_2 and v_3 denote the average velocities in the three successive intervals of time t_1, t_2 and t_3. Which of the following relations is correct ?

(A) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 + t_3)$

(B) $(v_1 - v_2) : (v_2 - v_3) = (t_1 + t_2) : (t_2 + t_3)$

(C) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_1 - t_3)$

(D) $(v_1 - v_2) : (v_2 - v_3) = (t_1 - t_2) : (t_2 - t_3)$

Q10. The engine of a motorcycle can produce a maximum acceleration 5 m/s^2. Its brakes can produce a maximum retardation 10 m/s^2. If motorcyclist start from point A and reach at point B. What is the minimum time in which it can cover if distance between A and B is 1.5 km: Given that motorcycle comes to rest at B.

(A) 30 sec (B) 15 sec

(C) 10 sec (D) 5 sec

Q11. Balls are thrown vertically upward in such a way that the next ball is thrown when the previous one is at the maximum height. If the maximum height is 5m, the number of balls thrown per minute will be :-

(A) 40 (B) 50

(C) 60 (D) 120

Q12. A parachutist drops freely from an aeroplane for 10 s before the parachute opens out. Then he descends with a net retardation of 2.5 m/s^2. If he bails out of the plane at a height of 2495 m and g = 10 m/s^2, hit velocity on reaching the ground will be :-

(A) 5 m/s (B) 10 m/s

(C) 15 m/s (D) 20 m/s

Q13. A lift is moving downward with constant velocity 10 m/s. A coin is dropped at height 5m from the floor of lift, find the time taken by coin to reach the floor :-

(A) 1 s (B) 0.5 s

(C) 2 s (D) 1.5 s

Q14. A lift is moving with velocity 10 m/s upward with acceleration 5 m/s^2 upwards. At the same instant of time, a coin is dropped from 7.5 m above the floor of lift, find distance travelled by the coin in ground frame before it strikes the floor :-

(A) 5 m (upward)

(B) 10 m (downward)

(C) 10 m (upward)

(D) 5 m (downward)

Q15. A, B, C and D are points in a vertical line such that AB = BC = CD. If a body falls from rest from A, then the times of descend through AB, BC and CD are in the ratio :-

(A) $1:\sqrt{3}:\sqrt{2}$

(B) $\sqrt{2}:\sqrt{3}:1$

(C) $\sqrt{3}:1:\sqrt{2}$

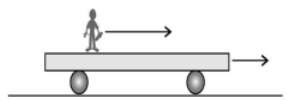
(D) $1:(\sqrt{2}-1):(\sqrt{3}-\sqrt{2})$

Q16. A particle is thrown upwards from ground. It experiences a constant resistance force which can produce retardation 2 m/s^2. The ratio of time of ascent to the time of descent is :- [g = 10 m/s^2]

(A) 1 : 1 (B) $\sqrt{\frac{2}{3}}$

(C) $\frac{2}{3}$ (D) $\sqrt{\frac{3}{2}}$

Q17. A trolley is moving horizontally with a constant velocity of v m/s w.r.t. earth. A man starts running from one end of the trolley with a velocity 1.5v m/s w.r.t. to trolley. After reaching the opposite end, the man return back and continues running with a velocity of 1.5 v m/s w.r.t. the trolley in the backward direction. If the length of the trolley is L then the displacement of the man with respect to earth during the process will be :-



(A) 2.5L (B) 1.5 L

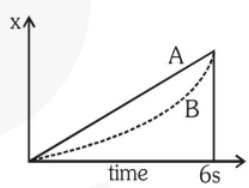
(C) $\frac{5L}{3}$ (D) $\frac{4L}{3}$

Q18. If force $F = \frac{Kq(Q-q)}{r^2}$ then condition for maximum force F is (K, Q and r are constants):-

(A) $q = \frac{Q}{4}$ (B) $q = \frac{Q}{2}$

(C) q = Q (D) q = 2Q

Q19. In the diagram shown, the displacement of particles is given as a function of time. The particle A is moving under constant velocity of 9 m/s. The particle B is moving under variable acceleration. From time t = 0 s. to t = 6 s., the average velocity of the particle B will be equal to :-



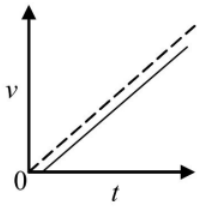
(A) 2.5 m/s (B) 4 m/s

(C) 9 m/s (D) None

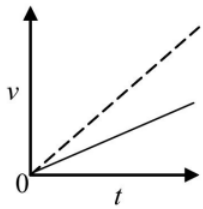
Q20. If an object is released in air, the magnitude of its acceleration would begin at the free-fall value, but it would decrease continuously to zero as the object continued to fall. For which one of the choices given does the solid line best represent the speed of the object as a function of time when it is dropped from rest in air?

Note: The dashed line shows the free-fall under vacuum graph for comparison.

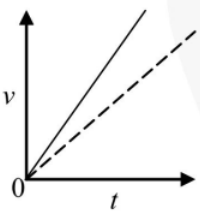
(A)



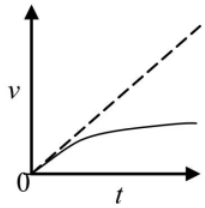
(B)



(C)



(D)



Q21. Acceleration of a particle is given by $a = 6x^2 - 4x + 5$ m/s^2. If the particle is initially at origin and moving with velocity of 20 m/s then velocity at x = 5m will be :-

(A) $\sqrt{450}$ m/s

(B) $\sqrt{650}$ m/s

(C) $\sqrt{850}$ m/s

(D) None of these

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A particle moves along the X–axis as $x = u(t-2) + a(t-2)^2$:-

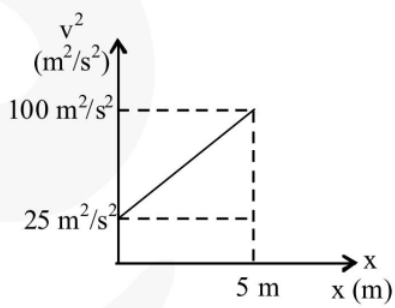
(A) The initial velocity of the particle is u

(B) The acceleration of the particle is a

(C) The acceleration of the particle is 2a

(D) At t = 2s particle is at the origin.

Q2. A particle is moving along x-axis and graph between square of speed and position of the particle is given in the figure. If at t = 0, x = 0 m, then select correct statement :-



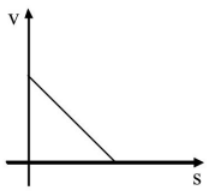
(A) Acceleration of the particle is 15 m/s^2 at $t = \frac{1}{2}$ s

(B) Acceleration of the particle is 7.5 m/s^2 at t = 1s

(C) Acceleration of the particle is constant

(D) At t = 1 s, velocity of particle is 12.5 m/s

Q3. Velocity-displacement graph of a particle moving in a straight line is as shown in figure :-



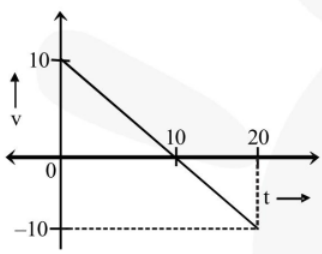
(A) magnitude of acceleration of particle is decreasing

(B) magnitude of acceleration of particle is increasing

(C) acceleration *versus* displacement graph is straight line

(D) acceleration *versus* displacement graph is parabola

Q4. The velocity-time plot for a particle moving on a straight line is shown in figure:-



(A) the particle has constant acceleration

(B) the particle has never turned around

(C) the particle has zero displacement

(D) the average speed in the interval 0 to 10 sec is same as the average speed in the interval 10 sec to 20 sec

Q5. A particle moves along a straight line and its velocity depends on time as $v = 4t - t^2$. Then for first five second :-

(A) Average velocity is 25/3 m/s

(B) Average speed is 10 m/s

(C) Average velocity is 5/3 m/s

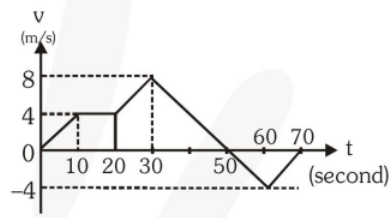
(D) Acceleration is 4 m/s^2 at t = 0

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

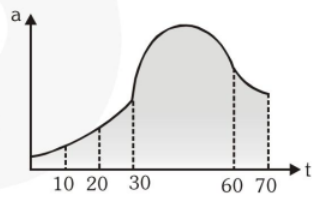
Paragraph for Question No. 6 to 10

A car is moving on a straight road. The velocity of the car varies with time as shown in the figure. Initially (at t = 0), the car was at x = 0, where, x is the position of the car at any time 't'.

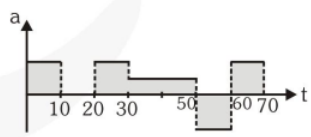


Q6. The variation of acceleration (a) with time (t) will be best represented by :-

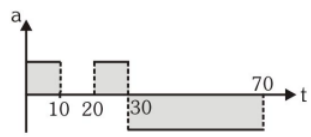
(A)



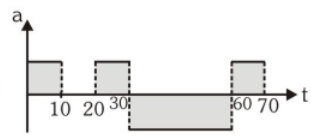
(B)



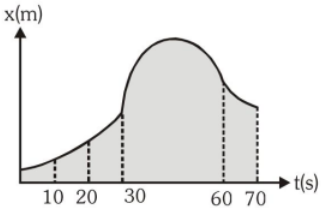
(C)

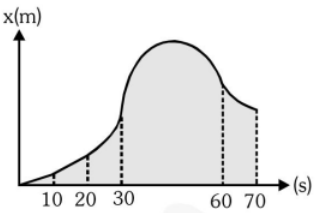


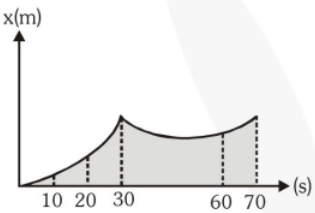
(D)

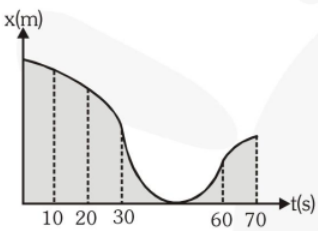


Q7. The displacement time graph will be best represented by :-

(A)


(B)


(C)


(D)


Q8. The maximum displacement from the starting position will be :-

(A) 200 m (B) 250 m

(C) 160 m (D) 165 m

Q9. Average speed from t = 0 to t = 70 s will be :-

(A) $\frac{16}{7}$ m/s (B) $\frac{24}{7}$ m/s

(C) $\frac{20}{7}$ m/s (D) zero

Q10. The time interval during which the car is retarding can be :-

(A) t = 50s to t = 70s

(B) t = 30s to t = 50s

(C) t = 30s to t = 60s

(D) t = 10s to t = 20s

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q11. A balloon rises up with constant net acceleration of $10 m/s^2$. After 2 s a particle drops from the balloon. After further 2 s match the following : (Take g = 10 m/s^2)

Column I	**Column II**
(A) Height of particle from ground	(p) Zero
(B) Speed of particle	(q) 10 SI units
(C) Displacement of Particle	(r) 40 SI units
(D) Acceleration of particle	(s) 20 SI units

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q12. A train, travelling at 20 km/hr is approaching a platform. A bird is sitting on a pole on the platform. When the train is at a distance of 2 km from pole, brakes are applied which produce a uniform deceleration in it to stop it at pole. At that instant the bird flies towards the train at 60 km/hr and after touching the nearest point on the train flies back to the pole and then flies towards the train and continues repeating itself. Calculate how much distance will the bird have flown before the train stops?

SUBJECTIVE TYPE

Q13. A juggler performs in a room whose ceiling is 3 m above the level of his hands. He throws a ball vertically upward so that it just reaches the ceiling.

(a) With what initial velocity does he throw the ball ?

(b) What time is required for the ball to reach the ceiling ?

He throws a second ball upward with the same initial velocity, at the instant that the first ball is at the ceiling.

(c) How long after the second ball is thrown do the two ball pass each other ?

(d) When the balls pass each other, how far are they above the juggler's hands ?

Q14. A particle is moving along x – axis with acceleration $a = a_0 (1 - t/T)$ where a_0 and T are constants. The particle at t = 0 has zero velocity. Calculate the average velocity between t = 0 and the instant when a = 0.

Q15. Two trains A and B 100 m and 60 m long are moving in opposite directions on the parallel tracks. The speed of shorter train is 3 times that of the longer one. If the train take 4 seconds to cross each other then find the velocities of the trains.

Answer Key

Ex-1									
1	2	3	4	5	6	7	8	9	10
A	C	A	B	A	A	A	D	B	A
11	12	13	14	15	16	17	18	19	20
C	D	C	C	A	C	D	A	B	C
21	22	23	24	25	26	27	28	29	30
B	C	B	C	C	C	C	D	A	B
31	32	33	34	35	36	37	38		
B	C	A	D	C	B	D	A		

Ex - 1A

1. B, D **2. A, C** **3. A, B** **4. A, C** **5. A, B, C**

6. A, B, C **7. A, B, D** **8. A, D** **9. A, C, D** **10. A, B, C, D**

11. A, B

12. A→q; B→p,q; C→p,r; D→r,s

13. A→p; B→v; C→s; D→q; E→u; F→t; (G)– r

14. A→r; B→q; C→s; D→p; **15. D** **16. D** **17. A**

18. 18.5 m **19. 89 m** **20. 9**

21. (i) 20 m, (ii) 5 s

Ex-2										
1	2	3	4	5	6	7	8	9	10	11
D	C	A	C	A	A	A	D	B	A	C
12	13	14	15	16	17	18	19	20	21	
A	A	A	D	B	D	B	C	D	C	

Ex - 2A

1. C, D **2.** B,C,D **3.** A, C **4.** A,C,D **5.** C, D

6. D **7.** B **8.** A **9.** B **10.** B

11. A→r; B→p; C→s; D→q **12.** 12 km

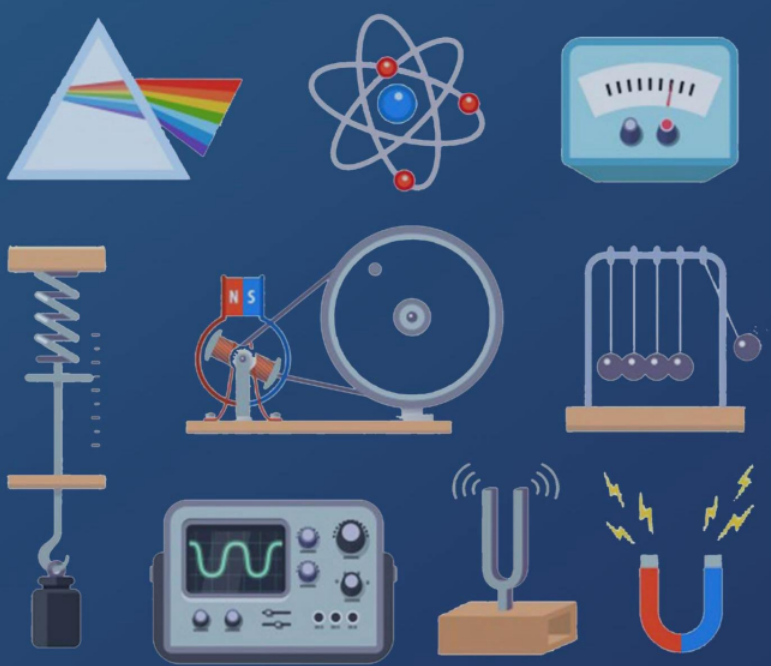
13. (a) $\sqrt{60}$ m/s, (b) $\sqrt{\frac{3}{5}}$ sec, (c) $\frac{3}{\sqrt{60}}$ sec, (d) $\frac{9}{4}$ m

14. $\frac{a_0 T}{3}$

15. $V_A = 10$ m/s , $V_B = 30$ m/s

PHYSICS

Kinetic Theory of Gases (KTG)



SHEET

Contents

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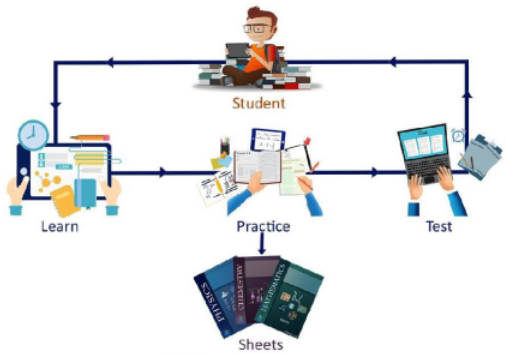
2.	Homework Index	Page - iii
3.	Exercise 1	Page - 1
4.	Exercise 1A	Page - 2
5.	Exercise 2	Page - 3
6.	Exercise 2A	Page - 4
7.	Answer Key	Page - 6

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Ideal Gas Equation - Part 1	1-5	1,2	1-5	1-3,6
2	Ideal Gas Equation - Part 2	6,7	3		4,7
3	Degree of Freedom	8,9	5,6	7, 9	5,8
4	Mean Free Path	10			
5	After Full Chapter	11	4	6, 8	

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Ideal Gas Equation - Part 1

Q1. Three containers of the same volume contain three different gases at same temp. The masses of the molecules are m_1, m_2 and m_3 and the number of molecules in their respective containers are N_1, N_2 and N_3. The gas pressure in the containers are P_1, P_2 and P_3 respectively. All the gases are now mixed and put in one of the containers. The pressure P of mixture will be :–

(A) $P < (P_1 + P_2 + P_3)$

(B) $P = \frac{P_1 + P_2 + P_3}{3}$

(C) $P = P_1 + P_2 + P_3$

(D) $P > (P_1 + P_2 + P_3)$

Q2. If rms velocity of a gas is V_{rms} = 1840 m/s and its density $\rho = 8.99 \times 10^{-2}$ kg/m^3, the pressure of the gas will be -

(A) 1.01 N/m^2

(B) 1.01×10^3 N/m^2

(C) 1.01×10^5 N/m^2

(D) 1.01×10^7 N/m^2

Q3. The volume of an ideal gas is V at pressure P and temperature T . The mass of each molecule of the gas is m. The density of gas will be :- (k is Boltzmann's constant)

(A) mkT (B) $\frac{Pm}{kT}$

(C) $\frac{P}{kTV}$ (D) $\frac{P}{kT}$

Q4. The number of oxygen molecules in a cylinder of volume 1 m^3 at a temperature of 27°C and pressure 13.8 Pa is (Boltzmaan's constant $k=1.38 \times 10^{-23}$ JK^{-1}) is :-

(A) 6.23×10^{26} (B) 0.33×10^{28}

(C) 3.3×10^{21} (D) none of these

Q5. The rms speed of an ideal diatomic gas at temperature T is v. When gas dissociates into atoms then its new rms speed becomes double. The temperature at which the gas dissociated into atoms was :-

(A) T (B) $\sqrt{2}$ T

(C) $\frac{T}{2}$ (D) 2T

Ideal Gas Equation - Part 2

Q6. **Statement–1 :** A real gas behaves as an ideal gas at high temperature and low pressure.

Statement–2 : Liquid state of an ideal gas is impossible.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is True; Statement–2 is not a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Q7. The thermodynamic co-ordinates of a jar filled with gas A are P, V and T and another jar B filled with another gas are 2P, $\frac{V}{4}$ and 2T, where the symbols have their usual meaning. The ratio of the number of molecules of jar A to those of jar B is :–

(A) 4 : 1 (B) 2 : 1

(C) 1 : 2 (D) 1 : 1

Degree of Freedom

Q8. Mean kinetic energy (or average energy) per gram molecule of a monoatomic gas is given by :–

(A) $\frac{3}{2}RT$ (B) $\frac{1}{2}kT$

(C) $\frac{1}{2}RT$ (D) $\frac{3}{2}kT$

Q9. Two monoatomic ideal gas at temperature T_1 and T_2 are mixed. There is no loss of energy. If the masses of molecules of the two gases are m_1 and m_2 and number of their molecules are n_1 and n_2 respectively. The temperature of the mixture will be :

(A) $\frac{T_1+T_2}{n_1+n_2}$ (B) $\frac{T_1}{n_1}+\frac{T_2}{n_2}$

(C) $\frac{n_2T_1+n_1T_2}{n_1+n_2}$ (D) $\frac{n_1T_1+n_2T_2}{n_1+n_2}$

Mean Free Path

Q10. If the pressure in a closed vessel is reduced by drawing out some gas, the mean free path of the molecules :-

(A) is decreased

(B) is increased

(C) remains unchanged

(D) increases or decreases according to the nature of the gas

After Full Chapter

Q11. Assume that the temperature remains essentially constant in the upper parts of the atmosphere. The atmospheric pressure varies with height as : (the mean molecular weight of air is M and P_0 = atomspheric pressure at ground reference)

(A) $P_0 e^{\frac{-3Mgh}{2RT}}$ (B) $P_0 e^{\frac{-Mgh}{2RT}}$

(C) $P_0 e^{\frac{-3Mgh}{RT}}$ (D) $P_0 e^{\frac{-Mgh}{RT}}$

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. 28 gm of N_2 gas is contained in a flask at a pressure of 10 atm and at a temperature of 57°C. It is found that due to leakage in the flask, the pressure is reduced to half and the temperature reduced to 27°C. The quantity of N_2 gas that leaked out is :-

(A) 11/20 gm (B) 20/11 gm

(C) 5/63 gm (D) 63/5 gm

Q2. Relation PV = RT is given for following condition for real gas :–

(A) high temperature and high density

(B) low temperature and low density

(C) high temperature and low density

(D) low temperature and high density

Q3. A gas is enclosed in a vessel at a constant temperature at a pressure of 5 atmosphere and volume 4 litre. Due to a leakage in the vessel, after some time, the pressure is reduced to 4 atmosphere. As a result, the

(A) volume of the gas decreased by 20%

(B) average K.E. of gas molecule decreases by 20%

(C) 20% of the gas escaped due to the leakage

(D) 25% of the gas escaped due to the leakage

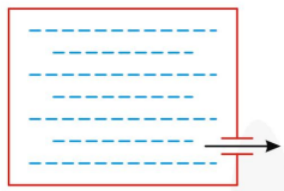
Q4. A vessel of volume V_0 contains an ideal gas at a pressure P_0. Gas is continuously pumped out of this vessel at a constant rate $\frac{dV}{dt} = r$, keeping the temperature constant. The pressure of the gas taken out equals the pressure inside the vessel. Find the pressure of the gas inside the vessel as a function of time.

(A) $2P_0 e^{-rt/V_0}$

(B) $3P_0 e^{-rt/V_0}$

(C) $-P_0 e^{-rt/V_0}$

(D) $P_0 e^{-rt/V_0}$



SUBJECTIVE TYPE

Q5. A cylinder of 200 litre capacity is containing H_2. The total average translational kinetic energy of molecules is 1.52×10^5 J.

The pressure of H_2 in the cylinder will be in N m^{-2} :-

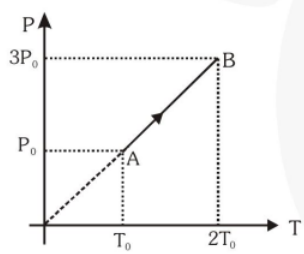
Q6. The ratio of average translational kinetic energy to rotational kinetic energy of a diatomic molecule at temperature T is :

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Pressure versus temperature graph of an ideal gas is shown in figure.Density of the gas at point A is ρ_0 . Density at B will be :-



(A) $\frac{3}{4}\rho_0$ (B) $\frac{3}{2}\rho_0$

(C) $\frac{4}{3}\rho_0$ (D) $2\rho_0$

Q2. At what temperature the V_{rms} of oxygen molecules will be equal to the escape velocity from the earths surface.

Given R = 8.3 J/K-mol &

escape speed = 11.2 km/s

(A) 1.61×10^5 K (B) 1.61×10^2 K

(C) 1.61×10^4 K (D) None of these

Q3. At temperature T, N molecules of gas A each having mass m and at the same temperature 2N molecules of gas B each having mass 2m are filled in a container. The mean square velocity of molecules of gas B is v^2 and mean square of x component of velocity of molecules of gas A is ω^2. The ratio of ω^2/v^2 is :

(A) 1 (B) 2

(C) 1/3 (D) 2/3

Q4. Three particles have speeds of 2u, 10u and 11u. Which of the following statements is correct ?

(A) The r.m.s. speed exceeds the mean speed by about u.

(B) The mean speed exceeds the r.m.s. speed by about u.

(C) The r.m.s. speed equals the mean speed.

(D) The r.m.s. speed exceeds the mean speed by more than 2u.

Q5. A container X has volume double that of container Y and both are connected by a thin tube. Both contains same ideal gas. The temperature of X is 200K and that of Y is 400K. If mass of gas in X is m then in Y it will be :

(A) m/8 (B) m/6

(C) m/4 (D) m/2

Q6. Two closed vessels of equal volume contain air at P_0 pressure, T_0 temperature and are connected through a narrow tube. If one of the vessel is now maintained at T_0 and other at T, what will be the pressure in the vessels.

(A) $\frac{2P_0}{T_0\left(\frac{1}{T}+\frac{1}{T_0}\right)}$ (B) $\frac{P_0}{T_0\left(\frac{1}{T}+\frac{1}{T_0}\right)}$

(C) $\frac{3P_0}{T_0\left(\frac{1}{T}+\frac{1}{T_0}\right)}$ (D) None of these

Q7. A vessel contains a mixture of one mole of oxygen and two moles of nitrogen at 300 K. The ratio of the average rotational kinetic energy per O_2 molecule to per N_2 molecule is :–

(A) 1 : 1 (B) 1 : 2

(C) 2 : 1

(D) depends on the moment of inertia of the two molecules

Q8. Air is filled at 60°C in a vessel of open mouth. The vessel is heated to a temperature T so that $\frac{1}{4}$th part of air escapes. The value of T is :–

(A) 171°C (B) 161°C

(C) 151°C (D) 181°C

Q9. Calculate the number of degrees of freedom of molecules of hydrogen in 1 cc of hydrogen gas at NTP.

(A) 1.344×10^{20}

(B) 1.344×10^{19}

(C) 1.344×10^{18}

(D) 1.344×10^{17}

Exercise - 2A *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. During experiment, an ideal gas is found to obey a condition P^2/ρ= constant [ρ = density of the gas]. The gas is initially at temperature T, pressure P and density ρ. The gas expands such that density changes to $\rho/2$.

(A) The pressure of the gas changes to $\sqrt{2}$ P

(B) The temperature of the gas changes to $\sqrt{2}$ T

(C) The graph of the above process on the P–T diagram is parabola

(D) The graph of the above process on the P–T diagram is hyperbola

Q2. If the pressure of a gas is doubled at constant temperature, then the mean square velocity will become :-

(A) no change (B) double

(C) four times (D) none of the above

Q3. A vessel is partitioned in two equal halves by a fixed diathermic separator. Two different ideal gases are filled in left (L) and right (R) halves. The rms speed of the molecules in L part is equal to the mean speed of molecules in the R part. Then the ratio of the mass of a molecule in L part to that of a molecule in R part is :-

(A) $\sqrt{\frac{3}{2}}$ (B) $\sqrt{\pi/4}$

(C) $\sqrt{2/3}$ (D) $3\pi/8$

Q4. A thin tube of uniform cross-section is sealed at both ends. It lies horizontally, the middle 5 cm containing mercury and the parts on its two sides containing air at the same pressure p. When the tube is held at an angle of 60° with the vertical, the length of the air column above and below the mercury pallet are 46 cm and 44.5 cm respectively. Calculate the pressure p in centimetres of mercury. The temperature of the system is kept at 30°C.

(A) 75.39 cm

(B) 54.39 cm

(C) 64.39 cm

(D) 85.39 cm

Q5. The temperature of an ideal gas consisting of rigid diatomic molecules is T = 300K. Calculate the angular root mean square velocity of a rotating molecule if its moment of inertia is equal to $I = 2.1\times10^{-39}\ g\,cm^2$.

(A) 6.3×10^{12} rad / sec

(B) 6.8×10^{12} rad / sec

(C) 3.6×10^{12} rad / sec

(D) 3.2×10^{12} rad / sec

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q6. At a temperature T K, the pressure of 4.0g argon in a bulb is p. The bulb is put in a bath having temperature higher by 50K than the first one. 0.8g of argon gas had to be removed to maintained original pressure. The temperature T is equal to

SUBJECTIVE TYPE

Q7. A vessel of volume $8.3 \times 10^{-3}\ m^3$ contains an ideal gas at temperature 27°C and pressure 200 kPa. The gas is allowed to leak till the pressure falls to 100 kPa and temperature increases to 327°C. What is the amount of gas in moles will be leaked out?

Q8. A gas mixture consists of 2 moles of oxygen and 4 moles of argon at temperature T. Neglecting all vibrational modes, the total internal energy of the system is :-

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	C	B	C	D	B	A	A	D	B
11									
D									

Ex-1A

1. D **2.** C **3.** C **4.** D **5.** 5×10^5 N/m^2

6. 3/2

Ex-2								
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
B	A	D	A	C	A	A	A	A

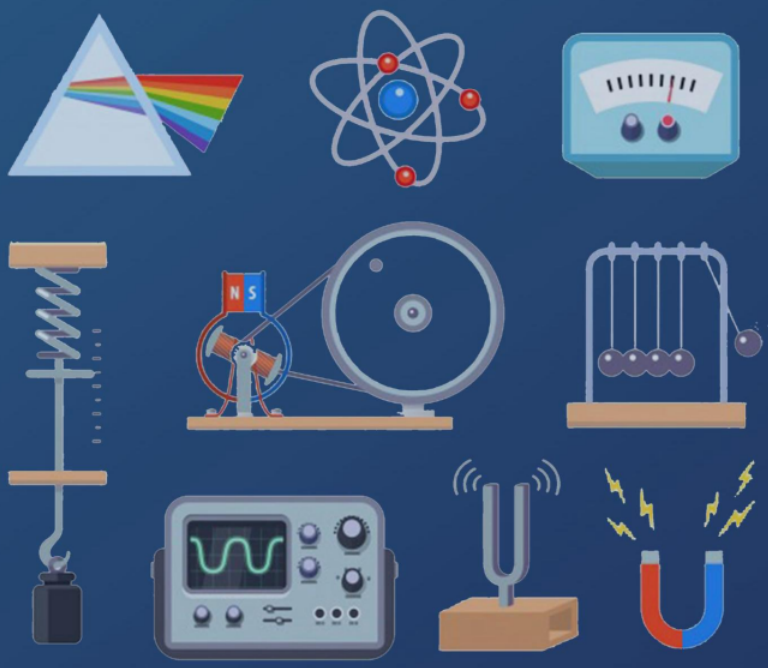
Ex-2A

1. B,D **2.** A **3.** D **4.** A **5.** A

6. 200 K **7.** $\frac{1}{2}$ mole **8.** 11RT

PHYSICS

Magnetic Effect of Current



SHEET

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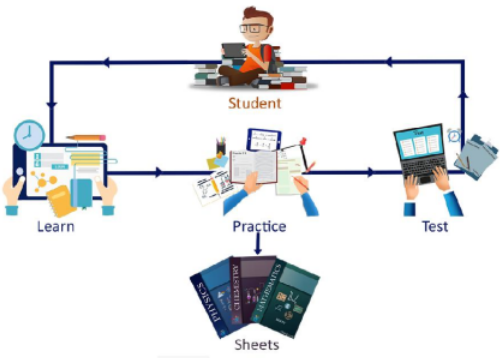
7.	Answer Key	Page - 22

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Biot - Savart Law	1			
2	Magnetic field due to straight finite current carrying wire	2		1-4	
3	Magnetic field Lines due to straight infinite current carrying wire	3-5	1,2	5-10	1
4	Magnetic field due to straight current carrying wire	6	3,4		
5	Magnetic field due to circular current loop	7-10	14	11	
6	Ampere's circuital law		10	12	
7	Magnetic field due to long cylinders		5	13-16	2,3,18-20
8	Solenoid and Toroid	11-13	15		
9	Magnetic force on a moving charged particle	14-17		17-20	
10	Motion of particle in magnetic field	18-21	6,11	21-29	4-6
11	Helical path		13	30	7,8,21-24, 33
12	Motion of particle in combined electric and magnetic field	22-24	7	31	9,10, 25-28
13	Cyclotron			32.33	
14	Hall effect			34	
15	Magnetic force on a current carrying wire	25,26		35-38	11
16	Force between two parallel and perpendicular currents	27-30			29-32
17	Torque on a current loop	31,32	8,9	39-43	12,34
18	Circular current loop as a magnetic dipole	33	16		
19	Moving coil galvanometer				
20	After full Chapter		12		13-17

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Biot - Savart Law

Q1. The vector form of Biot savart law for a current carrying element is :–

(A) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{id\ell \sin\phi}{r^2}$

(B) $d\vec{B} = \frac{\mu_0}{4\pi}\frac{i\vec{d\ell} \times \hat{r}}{r^2}$

(C) $\vec{B} = \frac{\mu_0}{4\pi}\frac{i\vec{d\ell} \times \hat{r}}{r^3}$

(D) $\vec{B} = \frac{\mu_0}{4\pi}\frac{i\vec{d\ell} \times \vec{r}}{r^2}$

Magnetic field due to straight finite current carrying wire

Q2. A vertical straight conductor carries a current vertically upwards. A point P lies to the east of it at a small distance and another point Q lies to the west at the same distance. The magnetic field at P is :-

(A) Greater than at Q

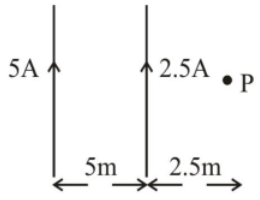
(B) Same as at Q

(C) Less than at Q

(D) Greater or less than at Q, depending upon the strength of current

Magnetic field due to straight infinite current carrying wire

Q3. Magnetic field at point 'P' due to both infinite long current carrying wires is :-



(A) $\frac{\mu_0}{2\pi}\otimes$ (B) $\frac{5\mu_0}{6\pi}\otimes$

(C) $\frac{5\mu_0}{6\pi}\odot$ (D) $\frac{\mu_0}{2\pi}\odot$

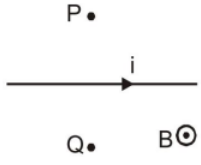
Q4. A long, straight wire carrying a current of 1.0 A is placed horizontally in a uniform magnetic field B = 1.0×10^{-5} T pointing vertically upward (figure). The magnitude of the resultant magnetic field at the points P and Q, both situated at a distance of 2.0 cm from the wire in the same horizontal plane are respectively

(A) zero, 20 μT

(B) 20 μT, zero

(C) zero, zero

(D) 20 μT, 20 μT



Q5. A current of 10 A is established in a long wire along positive z -direction. The magnetic field B at the point (1m, 0, 0) is :-

(A) 1 μT along the –y direction

(B) 2μT along the +y direction

(C) 1μT along the –x direction

(D) 2μT along the +x direction

Magnetic field Line due to straight current carrying wire

Q6. Due to a finitely long current carrying wire, magnetic field lines will be-

(A) Straight lines

(B) Concentric circles with centres on the wire

(C) Both A snd B

(D) None of these

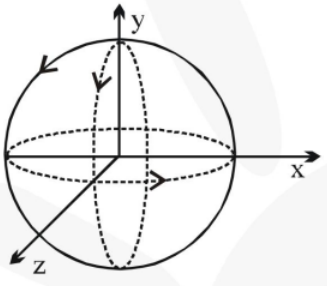
Magnetic field due to circular current loop

Q7. A circular coil of one turn is formed by a 6.28m length wire, which carries a current of 3.14A. The magnetic field at the centre of coil is :-

(A) 1×10^{-6} T (B) 4×10^{-6} T

(C) 0.5×10^{-6} T (D) 2×10^{-6} T

Q8. Three rings, each having equal radius R, are placed mutually perpendicular to each other and each having its centre at the origin of co-ordinate system. If current I is flowing through each ring then the magnitude of the magnetic field at the common centre is -



(A) $\sqrt{3}\frac{\mu_0 I}{2R}$ (B) zero

(C) $\left(\sqrt{2}-1\right)\frac{\mu_0 I}{2R}$ (D) $\left(\sqrt{3}-\sqrt{2}\right)\frac{\mu_0 I}{2R}$

Q9. Two concentric coils X and Y of radii 16 cm and 10 cm lie in the same vertical plane containing N-S direction. X has 20 turns and carries 16 A. Y has 25 turns & carries 18A. X has current in anticlockwise direction and Y has current in clockwise direction for an observer, looking at the coils facing the west. The magnitude of net magnetic field at their common centre is -

(A) $5\pi \times 10^{-4}$ T towards west

(B) $13\pi \times 10^{-4}$ T towards east

(C) $13\pi \times 10^{-4}$ T towards west

(D) $5\pi \times 10^{-4}$ T towards east

Q10. A length of wire carries a steady current, is bent first to form a plane circular coil of one turn, same length now bent more sharply to give three turns of smaller radius. Magnetic field becomes:

(A) 3 times (B) 1/3 times

(C) 9 times (D) unchange

Solenoid and Toroid

Q11. A closely wound solenoid 80 cm long has 5 layers of windings of 400 turns each. The diameter of the solenoid is 1.8 cm. If the current carried is 8.0 A. estimate the magnitude of B inside the solenoid near its centre.

(A) zero (B) $8\pi \times 10^{-3}$ T

(C) $15\pi \times 10^{-3}$ T (D) $\pi \times 10^{-3}$ T

Q12. If number of turns and current becomes double for any solenoid, then value of magnetic field becomes :-

(A) twice (B) same

(C) half (D) four times

Q13. Mean radius of a toroid is 10 cm and number of turns are 500. If current flowing through it is 0.1 ampere then value of magnetic field (in tesla) for toroid :-

(A) 10^{-2} (B) 10^{-5}

(C) 10^{-3} (D) 10^{-4}

Magnetic force on a moving charged particle

Q14. A test charge $1{\cdot}6 \times 10^{-19}$ C is moving with velocity $\vec{v} = (2\hat{i} + 3\hat{j})$ m/sec in a magnetic field $\vec{B} = (2\hat{i} + 3\hat{j})$ Wb/m^2. The magnetic force on the test charge :-

(A) $6\hat{k}$T

(B) $\left(4\hat{i}+6\hat{j}\right)$T

(C) $\left(4\hat{i}+6\hat{j}\right)\times 10^{-19}$T

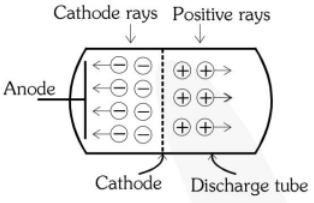
(D) zero

Q15. In a region a uniform magnetic field acts in horizontal plane towards north. If cosmic particles (80% protons) falling vertically downwards, then they are deflected towards-

(A) North (B) South

(C) East (D) West

Q16. A magnetic field is applied at perpendicular to the axis of cylinderical discharge tube then cathode and positive rays deflected in -



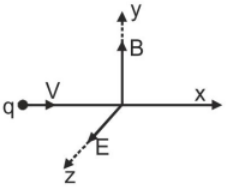
(A) Same direction.

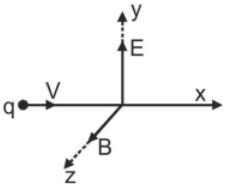
(B) Opposite direction.

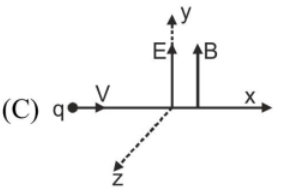
(C) Mutually perpendicular direction.

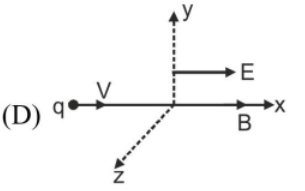
(D) No deflection for both.

Q17. A particle of charge q and mass m is moving along the x-axis with a velocity v and enters a region of electric field E and magnetic field B as shown in figure beolw. For which figure the net force on the charge may be zero :-

(A)


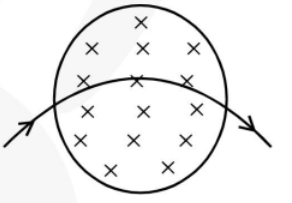
(B)


(C)


(D)


Motion of particle in magnetic field

Q18. There is a magnetic field acting in a plane perpendicular downwards. A particle in vacuum moves in the plane of paper from left to right as shown in figure. The path indicated by the arrow could be due to -



(A) Proton (B) Neutron

(C) Electron (D) Alpha particle

Q19. **Statement–1** : A magnetic field may interacts with a moving charge and not with a stationary charge.

Statement–2 : A moving charge produces a magnetic field.

(A) Statement–1 is True, Statement–2 is False.

(B) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is True ; Statement–2 is NOT a correct explanation for Statement–1.

(D) Statement–1 is False, Statement–2 is True.

Q20. An electron makes 3×10^5 revolutions per second in a circle of radius 0.5 angstrom. Find the magnetic field B at the centre of the circle.

(A) 6×10^{-10} T (B) 12×10^{-10} T

(C) 18×10^{-10} T (D) 24×10^{-10} T

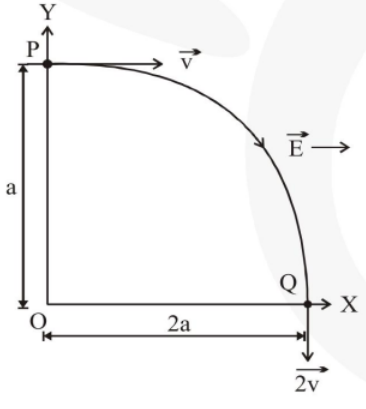
Q21. Which of the following charge has maximum frequency of rotation in uniform transverse magnetic field :-

(A) a proton (B) an alpha particle

(C) an electron (D) a neutron

Motion of particle in combined electric and magnetic field

Q22. A particle of charge +q and mass m moving under the influnce of a uniform electric field $E\hat{i}$ and a uniform magnetic field $B\hat{k}$ follows trajectory from P to Q as shown in figure. The velocities at P and Q $v\hat{i}$ and $-2v\hat{j}$ respectively. Which of the following statement is incorrect -



(A) $E = \frac{3}{4}\left[\frac{mv^2}{qa}\right]$

(B) Rate of work done by electric field at P is $\frac{3}{4}\left[\frac{mv^3}{a}\right]$

(C) Rate of work done by electric field at P is zero

(D) Rate of work done by both the fields at Q is zero

Q23. Electric field strength $\vec{E} = E_0\hat{i}$ and $\vec{B} = B_0\hat{i}$ exists in a region. A charge is projected with a velocity $\vec{v} = v_0\hat{j}$ at origin, then -

(A) It moves along helix with constant pitch

(B) It moves along circular path in YZ plane

(C) It moves along helix with increasing pitch

(D) It moves along helix with decreasing pithch

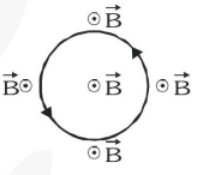
Q24. A charged particle is released from rest in a region of steady and uniform electric and magnetic fields which are parallel to each other. The particle will move in a :

(A) straight line (B) circle

(C) helix (D) cycloid

Magnetic force on a current carrying wire

Q25. An elastic circular wire of length ℓ carries a current I_0 It is placed in a uniform magnetic field $\vec{B}$ (out of paper) such that its plane is perpendicular to the direction of $\vec{B}$. The wire will experience:



(A) no force

(B) a stretching force

(C) a compressive force

(D) a torque

Q26. A conductor in the form of a right angle ABC, with AB=3cm and BC = 4cm, carries a current of 10A. There is a uniform magnetic field of 5T perpendicular to the plane of the conductor. The force on the conductor will be :-

(A) 1.5N (B) 2.0N

(C) 2.5N (D) 3.5N

Force between two parallel and perpendicular currents

Q27. **Statement–1 :** A solenoid tends to expand, when a current passes through it.

Statement–2 : Two straight parallel metallic wires carrying current in opposite direction attract each other.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

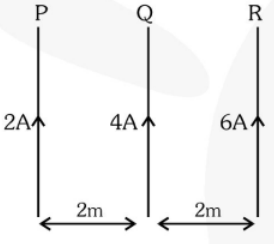
(B) Statement–1 is True, Statement–2 is True; Statement–2 is NOT a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Both Statement–1 and Statement-2 are False.

Q28. Three long straight wires, carries currents are arranged according to figure.

Magnetic force on 10cm part of wire Q is:



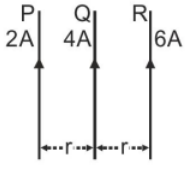
(A) 16×10^{-9} N, towards right

(B) 16×10^{-8} N, towards right

(C) 16×10^{-8} N, towards left

(D) 16×10^{-9} N, towards left

Q29. P, Q and R long parallel straight wires in air, carrying currents as shown. The direction of resultant force on R is :-



(A) towards left

(B) towards right

(C) the same as that of current in Q

(D) perpendicular to plane of paper

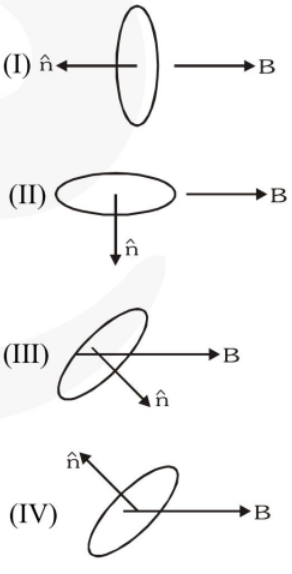
Q30. Three long straight conductors are arranged parallel to each other in the same plane and carry currents of 1 A, 2 A and 3 A all in the same direction. The distance between the first two conductors is "x" and the distance between the second and third conductors is "y". If the middle conductor is in equilibrium, the ratio x : y is

(A) 1 : 3 (B) 3 : 1

(C) 1 : $\sqrt{3}$ (D) $\sqrt{3}$: 1

Torque on a current loop

Q31. A current carrying loop is placed in a uniform magnetic field in four different orientations, I, II, III, IV, arrange them in the decreasing order of potential energy :



(A) I > III > II > IV

(B) I > II > III > IV

(C) I > IV > II > III

(D) III > IV > I > II

Q32. Two particles, each of mass m and charge q, are attached to the two ends of a light rigid rod of length 2R. The rod is rotated at constant angular speed about a perpendicular axis passing through its centre. The ratio of the magnitudes of the magnetic moments of the system and its angular momentum about the centre of the rod is :

(A) q/2m (B) q/m

(C) 2q/m (D) q/πm

Circular Current Loop as a Magnetic Dipole

Q33. A circular loop has a radius of 5 cm. and it is carrying a current of 0.1 Amp. its magnetic moment is :–

(A) 1.32×10^{-4} amp × m^2

(B) 2.62×10^{-4} amp × m^2

(C) 5.25×10^{-4} amp × m^2

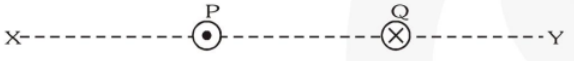
(D) 7.85×10^{-4} amp × m^2

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Two long and parallel wires at P and Q carry currents 0.1 A and 0.2 A respectively in opposite directions as shown.



In which region(s) a neutral point may not exist, that is where the magnetic field is not zero?

(A) Between X and P

(B) Between P and Q

(C) Between Q and Y

(D) In all the regions there exists no neutral point

Q2. A long straight wire carries a current along the x-axis. Consider the points A(0, 1, 0), B(0, 1, 1), C(1, 0, 1) and D(1, 1, 1). Which of the following pairs of points will have magnetic fields of the same magnitude?

(A) A and B (B) A and C

(C) B and C (D) B and D

Q3. Consider the magnetic field produced by a finitely long current carrying wire

(A) The lines of field will be concentric circles with centres on the wire.

(B) There can be two points in the same plane where magnitude of magnetic fields are same.

(C) There can be large number of points where magnitude of magnetic field is same.

(D) The magnetic field at a point is inversely proportional to the distance of the point from the wire.

Q4. The magnetic lines of force due to a straight current carrying wire will be:

(A) circular for finite length of wire

(B) circular for semi-infinite wire

(C) circular for infinite wire

(D) Parabolic for finite wire

Q5. A current I flows along the length of an infinitely long, straight, solid pipe. Then correct statement(s)-

(A) The magnetic field is zero only on the axis of the pipe.

(B) The magnetic field is different at different points inside the pipe.

(C) The magnetic field is maximum on surface.

(D) The magnetic field at all points inside the pipe is the same, but not zero.

Q6. An electron is moving along the positive X-axis. You want to apply a magnetic field for a short time so that the electron may reverse its direction and move parallel to the negative X–axis. This can be done by applying the magnetic field along :-

(A) Y-axis

(B) Z-axis

(C) Y-axis only

(D) Z-axis only

Q7. If a charge projected in a zero gravity region. Find possible cases of electric and magnetic field in that region so no net force exerts on charge.

(A) $E = 0, B = 0$

(B) $E = 0, B \neq 0$

(C) $E \neq 0, B \neq 0$

(D) $E \neq 0, B = 0$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 8 & 9

Torque acting on a current loop in uniform magnetic field is given by $\vec{\tau} = \vec{M} \times \vec{B}$. But force on it is zero. If it is free to rotate then it will rotate about an axis passing through its centre of mass and parallel to $\vec{\tau}$. The potential energy of loop is given by $U = -\vec{M}.\vec{B}$. A current carrying ring with its centre at origin and moment of inertia 10^{-2} kg–m^2 about an axis passing through its centre and perpendicular to its plane has magnetic moment $\vec{M} = (3\hat{i} - 4\hat{j})$ A–m^2. At time $t = 0$ a magnetic field $\vec{B} = (4\hat{i} - 3\hat{j})$ T is switched on.

Q8. Angular acceleration of the ring at time $t = 0$ in rad/s^2 is -

(A) 5000

(B) 1250

(C) 2500

(D) zero

Q9. Maximum angular velocity of the ring in rad/s will be :

(A) $50\sqrt{2}$

(B) $25\sqrt{2}$

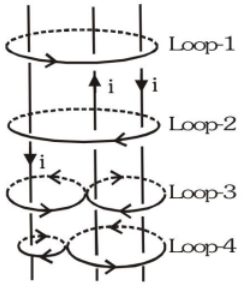
(C) $100\sqrt{2}$

(D) $150\sqrt{2}$

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q10. Three wires are carrying same constant current i in different directions. Four loops enclosing the wires in different manners are shown. The direction of $d\vec{\ell}$ is shown in figure.



Column I	Column II
(A) Along closed loop–1	(p) $\oint \vec{B}.d\vec{\ell} = \mu_0 i$
(B) Along closed loop–2	(q) $\oint \vec{B}.d\vec{\ell} = -\mu_0 i$
(C) Along closed loop–3	(r) $\oint \vec{B}.d\vec{\ell} = 0$
(D) Along closed loop–4	(s) Net work done by the magnetic force to move a unit charge along the loop is zero.

Q11. A charged particle is moving in a circular path in uniform magnetic field. Match the following:

Table–I	Table–II
(A) Equivalent current due to motion of charge particle	(p) is proportional to v
(B) Magnetic moment	(q) is proportional to v^2
(C) Magnetic field at centre of circle due to motion of charged Particle.	(r) is proportional to v^0
	(s) None

Q12.

Column I	Column II
(A) A charge at rest produces	(p) Magnetic field
(B) A charge moving with uniform velocity produces	(q) Electric field
(C) An accelerated charge produces	(r) Electromagnetic waves

NUMERICAL TYPE

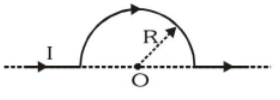
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q13. A beam of proton moving with velocity 4 $\times 10^5$ m/sec enters in a uniform magnetic field of 0.3 T at an angle of 60° to the magnetic field. Calculate radius of helical path and pitch of helix.

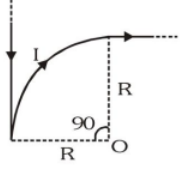
SUBJECTIVE TYPE

Q14. Find out magnetic field at point 'O' for the following current distributions.

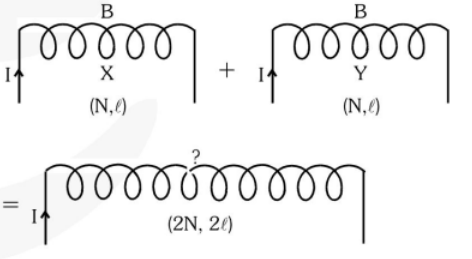
(a)



(b)



Q15. Two identical long solenoids X and Y carries equal current. The magnetic field produced at their axial mid point is B. If both the solenoids joined to each other according to figure. Find magnetic field at axial mid point of new solenoid.

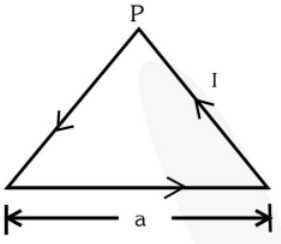


Q16. Two identical current carrying coils are concentric and perpendicular to each other. If magnetic moment of each coil is 'M'. Find resultant magnetic moment of two coils.

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

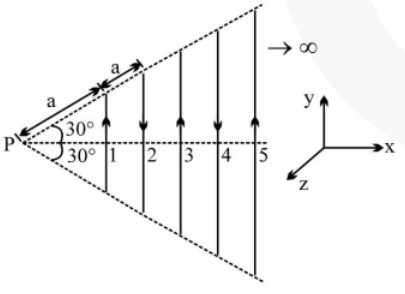
Q1. An equilateral triangle of side 'a' carries a current 'I'. Magnetic field at point 'P' which is vertex of triangle. :-



(A) $\frac{\mu_0 I}{2\sqrt{3}\pi a}$ □ (B) $\frac{\mu_0 I}{2\sqrt{3}\pi a}\otimes$

(C) $\frac{9}{2}\left(\frac{\mu_0 I}{\pi a}\right)$ □ (D) $\frac{9}{2}\left(\frac{\mu_0 I}{\pi a}\right)\otimes$

Q2. Infinite number of straight wires each carrying current I are equally placed as shown in the figure. Adjacent wires have current in opposite direction. Net magnetic field at point P is -



(A) $\frac{\mu_0 I}{4\pi}\frac{\ln 2}{\sqrt{3}\,a}\hat{k}$ (B) $\frac{\mu_0 I}{4\pi}\frac{\ln 4}{\sqrt{3}\,a}\hat{k}$

(C) $\frac{\mu_0 I}{4\pi}\frac{\ln 4}{\sqrt{3}\,a}(-\hat{k})$ (D) Zero

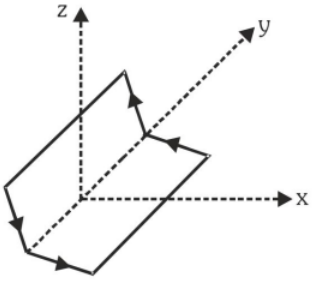
Q3. A non–planar loop of conducting wire carrying a current I is placed as shown in the figure. Each of the straight sections of the loop is of length 2a. The magnetic field due to this loop at the point P (a, 0, a) points in the direction :

(A) $\frac{1}{\sqrt{2}}\left(-\hat{j}+\hat{k}\right)$

(B) $\frac{1}{\sqrt{3}}\left(-\hat{j}+\hat{k}+\hat{i}\right)$

(C) $\frac{1}{\sqrt{3}}\left(\hat{i}+\hat{j}+\hat{k}\right)$

(D) $\frac{1}{\sqrt{2}}\left(\hat{i}+\hat{k}\right)$



Q4. Consider a 10 cm long piece of a wire which carries a current of 10 A. Find the magnitude of the magnetic field due to the piece at a point which makes an equilateral triangle with the ends of the piece.

(A) Zero (B) 5.5 μT

(C) 7.5 μT (D) 11.5 μT

Q5. A straight wire carries current in vertical upward direction. A point 'P' lies just east of it at a small distance and another point 'Q' lies to the west just same distance. The magnetic field at these points :-

(consider earth magnetic field)

(A) $B_P > B_Q$ (B) $B_P < B_Q$

(C) $B_P = B_Q$ (D) None

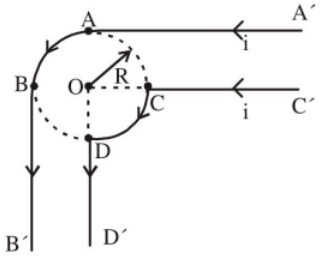
Q6. All straight wires are very long. Both AB and CD are arc of the same circle, both subtending right angles at the centre O. Then the magnetic field at O is

(A) $\frac{\mu_0 i}{4\pi R}$

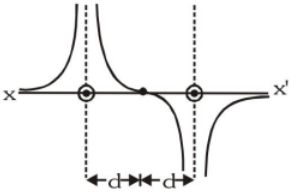
(B) $\frac{\mu_0 i}{4\pi R}\sqrt{2}$

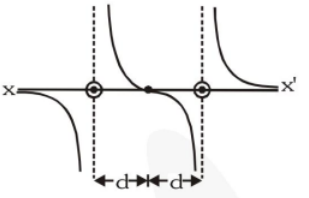
(C) $\frac{\mu_0 i}{2\pi R}$

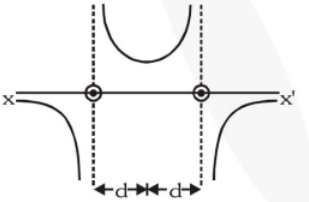
(D) $\frac{\mu_0 i}{2\pi R}(\pi+1)$

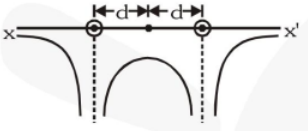


Q7. Two long parallel wires are at a distance 2d apart. They carry steady equal currents flowing out of the plane of the paper as shown. The variation of the magnetic field B along the line XX' is given by :

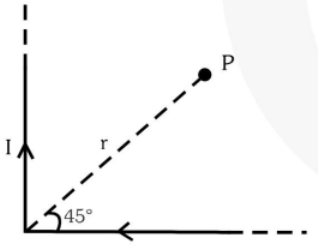
(A) 

(B) 

(C) 

(D) 

Q8. Magnetic field at point 'P' due to given current distribution is :-



(A) $\frac{\mu_0 I}{4\pi r}\left(1+\sqrt{2}\right)$ ⊡

(B) $\frac{\mu_0 I}{2\pi r}\left(1+\sqrt{2}\right)$ ⊡

(C) $\frac{\mu_0 I}{4\pi r}\left(1+\sqrt{2}\right)\otimes$

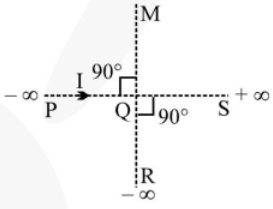
(D) $\frac{\mu_0 I}{2\pi r}\left(1+\sqrt{2}\right)\otimes$

Q9. A long straight wire along the z-axis carries a current I in the negative z direction. The magnetic vector field $\vec{B}$ at a point having coordinates (x, y) in the z = 0 plane is

(A) $\frac{\mu_0 I}{2\pi}\frac{(y\hat{i}-x\hat{j})}{(x^2+y^2)}$ (B) $\frac{\mu_0 I}{2\pi}\frac{(x\hat{i}+y\hat{j})}{(x^2+y^2)}$

(C) $\frac{\mu_0 I}{2\pi}\frac{(x\hat{j}-y\hat{i})}{(x^2+y^2)}$ (D) $\frac{\mu_0 I}{2\pi}\frac{(x\hat{i}-y\hat{j})}{(x^2+y^2)}$

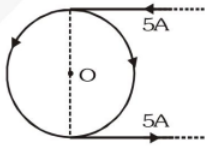
Q10. An infinitely long conductor PQR is bent to form a right angle as shown. A current I flows through PQR. The magnetic field due to this current at the point M is H_1. Now, another infinitely long straight conductor QS is connected at Q so that the current in PQ remaining unchanged. The magnetic field at M is now H_2. The ratio H_1/H_2 is given by:



(A) 1/2 (B) 1

(C) 2/3 (D) 2

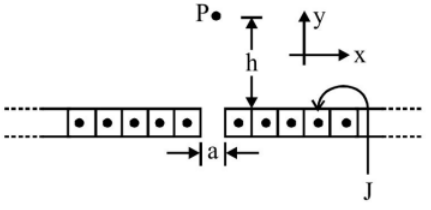
Q11. Magnetic field at point 'O' due to given current distribution. If 5A current is flowing in this system and the diameter of the loop is 10cm.



(A) 2×10^{-5} T, ⊗ (B) 10^{-5}T, ⊡

(X) 10^{-5} T, ⊡ (D) 2×10^{-5} T, ⊡

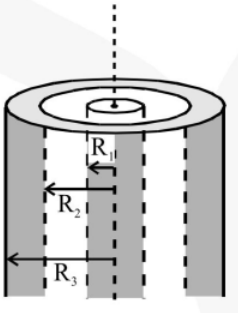
Q12. A small segment of length a is cut along z-axis from a infinite sheet having a surface current density J (current per unit width). The magnetic field at P is :-



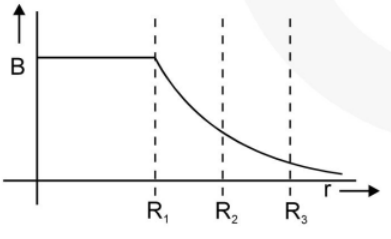
(A) $2\mu_0 J\left(1-\frac{h}{a\pi}\right)\hat{i}$ (B) $\frac{\mu_0 Jh}{2a\pi}\hat{i}$

(C) $\frac{\mu_0 J}{2}\left(\frac{a}{h\pi}-1\right)\hat{i}$ (D) $-\frac{\mu_0 j}{2}\left(\frac{h}{a\pi}-1\right)\hat{i}$

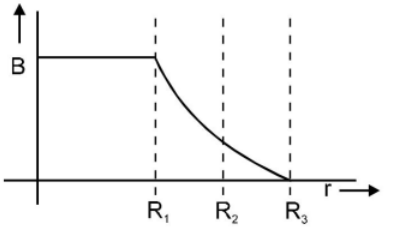
Q13. A coaxial cable is made up of two conductors. The inner conductor is solid and is of radius R_1 & the outer conductor is hollow of inner radius R_2 and outer radius R_3. The space between the conductors is filled with air. The inner and outer conductors are carrying currents of equal magnitudes and in opposite directions. Then the variation of magnetic field with distance from the axis is best plotted as:



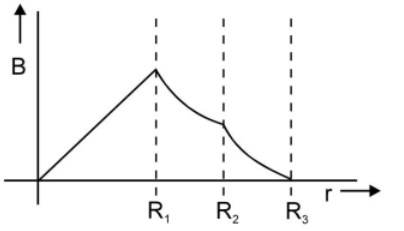
(A)



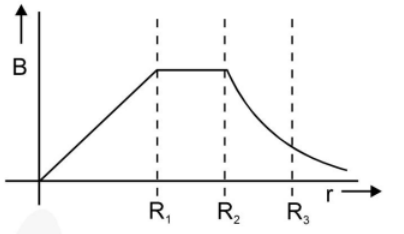
(B)



(C)



(D)



Q14. A long, cylindrical wire of radius b carries a current i distributed uniformly over its cross-section. Find the magnitude of the magnetic field at a point inside the wire at a distance a from the axis.

(A) zero (B) $\frac{\mu_0 ib}{2\pi a^2}$

(C) $\frac{\mu_0 ia^2}{2\pi b^3}$ (D) $\frac{\mu_0 ia}{2\pi b^2}$

Q15. A solid cylinderical wire of radius 'R' carries a current 'I'. The magnetic field is 5μT at a point, which is '2R' distance away from the axis of wire. Magnetic field at a point which is R/3 distance inside from the surface of the wire is :-

(A) $\frac{10}{3}\mu T$ (B) $\frac{20}{3}\mu T$

(C) $\frac{5}{3}\mu T$ (D) $\frac{40}{3}\mu T$

Q16. A hollow cylinderical wire carries a current I, having inner and outer radii 'R' and 2R respectively. Magnetic field at a point which 3R/2 distance away from its axis is :-

(A) $\frac{5\mu_0 I}{18\pi R}$ (B) $\frac{\mu_0 I}{36\pi R}$

(C) $\frac{5\mu_0 I}{36\pi R}$ (D) $\frac{5\mu_0 I}{9\pi R}$

Q17. A electron experiences a force $\left(4.0\hat{i}+3.0\hat{j}\right) \times 10^{-13}$ N in a uniform magnetic field when its velocity is $2.5\hat{k}\times10^{7}\,ms^{-1}$. When the velocity is redirected and becomes $\left(1.5\hat{i}-2.0\hat{j}\right)\times10^{7}\,ms^{-1}$, the magnetic force on the electron is zero. The magnetic field vector $\vec{B}$ is :

(A) $-0.075\hat{i}+0.1\hat{j}$ (B) $0.1\hat{i}+0.075\hat{j}$

(C) $0.075\hat{i}-0.1\hat{j}+\hat{k}$ (D) $0.075\hat{i}-0.1\hat{j}$

Q18. An electron moving with a velocity $\vec{V}_1 = 2\hat{i}$ m/s at a point in a magnetic field experiences a force $\vec{F}_1 = -2\hat{j}N$. If the electron is moving with a velocity $\vec{V}_2 = 2\hat{j}$ m/s at the same point, it experiences a force $\vec{F}_2 = +2\hat{i}\,N$. The force the electron would experience if it were moving with a velocity $\vec{V}_3 = 2\hat{k}$ m/s at the same point is -

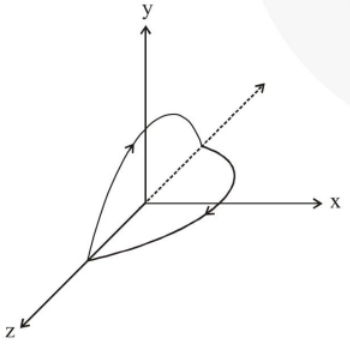
(A) zero

(B) $2\hat{k}N$

(C) $-2\hat{k}N$

(D) information is insufficient

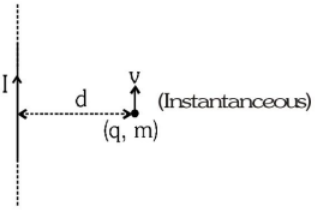
Q19. A non-planar circular loop consists of two semi-circles one of which lies in yz-plane & the other is in xz-plane as shown . The magnetic force experienced by positive charge of value Q moving with velocity v along x direction when it is at the origin is :



(A) $\frac{Qv\mu_0 I}{4R}$ (B) $\frac{Qv\mu_0 I}{2R}$

(C) $\frac{Qv\mu_0 I}{2\sqrt{2}R}$ (D) 0

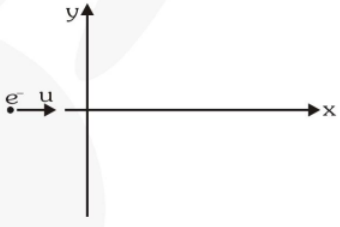
Q20. An electron is moving at 10^6 m/sec in a direction parallel to a current of 5A flowing through an infinite long straight wire separated by a perpendicular distance of 10cm in air. Magnetic force experienced by the electron :-



(A) 1.6×10^{-19} N (B) 1.6×10^{-20} N

(C) 1.6×10^{-18} N (D) 1.6×10^{-21} N

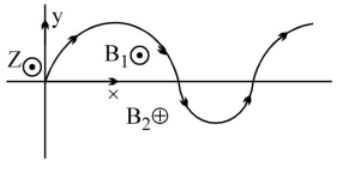
Q21. An electron moving with a speed u along the positive x–axis at y = 0 enters a region of uniform magnetic field $\vec{B} = -B_0\hat{k}$ which exists to the right of y–axis. The electron exits from the region after sometime with the speed v at co–ordinate y, then :



(A) $v > u,\ y < 0$ (B) $v = u,\ y > 0$

(C) $v > u,\ y > 0$ (D) $v = u,\ y < 0$

Q22. At t = 0 a charge q is at the origin and moving in the y-direction with velocity $\vec{v} = v\hat{j}$. The charge moves in a magnetic field that is for $y > 0$ out of page and given by $B_1\hat{z}$ and for $y < 0$ into the page and given $-B_2\hat{z}$. The charge's subsequent trajectory is shown in the sketch. From this information, we can deduce that :



(A) $q > 0$ and $|B_1| < |B_2|$

(B) $q < 0$ and $|B_1| < |B_2|$

(C) $q > 0$ and $|B_1| > |B_2|$

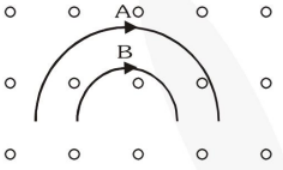
(D) $q < 0$ and $|B_1| > |B_2|$

Q23. A tightly-wound, long solenoid carries a current of 2.00 A. An electron is found to execute a uniform circular motion inside the solenoid with a frequency of 1.00×10^8 rev/s. Find the number of turns per metre in the solenoid.

(A) 500 Turns/m (B) 1020 Turns/m

(C) 1232 Turns/m (D) 1420 Turns/m

Q24. Two particles A and B of masses m_A and m_B respectively and having the same charge are moving in a plane. A uniform magnetic field exists perpendicular to this plane. The speeds of the particles are v_A and v_B respectively and the trajectories are as shown in the figure. Then :



(A) $m_A v_A < m_B v_B$

(B) $m_A v_A > m_B v_B$

(C) $m_A < m_B$ and $v_A < v_B$

(D) $m_A = m_B$ and $v_A = v_B$

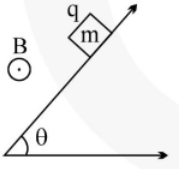
Q25. A block of mass m & charge q is released on a long smooth inclined plane magnetic field B is constant, uniform, horizontal and parallel to surface as shown. Find the time from start when block loses contact with the surface.

(A) $\frac{m\cos\theta}{qB}$

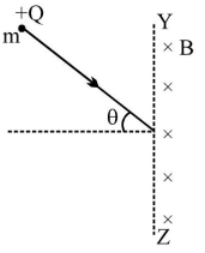
(B) $\frac{m\,\mathrm{cosec}\,\theta}{qB}$

(C) $\frac{m\cot\theta}{qB}$

(D) none



Q26. A particle with charge +Q and mass m enters a magnetic field of magnitude B, existing only to the right of the boundary YZ. The direction of the motion of the particle is perpendicular to the direction of B. Let $T = 2\pi\frac{m}{QB}$. The time spent by the particle in the field will be :



(A) Tθ (B) 2Tθ

(C) $T\left(\frac{\pi+2\theta}{2\pi}\right)$ (D) $T\left(\frac{\pi-2\theta}{2\pi}\right)$

Q27. In the previous question, if the particle has –Q charge, the time spend by the particle in the field will be :

(A) Tθ (B) 2Tθ

(C) $T\left(\frac{\pi+2\theta}{2\pi}\right)$ (D) $T\left(\frac{\pi-2\theta}{2\pi}\right)$

Q28. A particle of mass m and charge q moves with a constant velocity v along the positive x direction. It enters a region containing a uniform magnetic field B directed along the negative z direction, extending from x = a to x = b. The minimum value of v required so that the particle can just enter the region x > b is -

(A) qbB/m (B) q(b – a)B/m

(C) qaB/m (D) q(b + a)B/2m

Q29. H^+, He^+ and O^{++} all having the same kinetic energy pass throuth a region in which is a uniform magnetic field perpendicular to their velocity. The masses of H^+, He^+ and O^{++} are 1 amu, 4 amu and 16 amu respectively then :-

(a) H^+ will be deflected most

(b) O^{++} will be deflected most

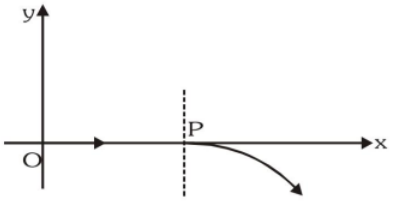
(c) He^+ and O^{++} will be deflected equally

(d) all will be deflected equally

(A) a, b (B) a, b, c

(C) only a (D) a, c

Q30. For a positively charged particle moving in a x – y plane initially along the x–axis, there is a sudden change in it path due to the presence of electric and/or magnetic field beyond P. The curved path is shown in the x – y plane and is found to be non–circular. Which one of the following combinations is possible?



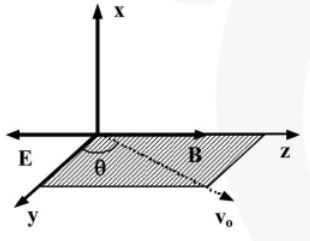
(A) $\vec{E}=0;\vec{B}=b\hat{j}+c\hat{k}$

(B) $\vec{E}=a\hat{i};\vec{B}=c\hat{k}+a\hat{i}$

(C) $\vec{E}=0;\vec{B}=c\hat{j}+b\hat{k}$

(D) $\vec{E}=a\hat{i};\vec{B}=c\hat{k}+b\hat{j}$

Q31. In a certain region uniform electric field E and magnetic field B are present in the opposite direction. At the instant t = 0, a particle of mass m carrying a charge q is given velocity v_o at an angle θ, with the y axis, in the yz plane. The time after which the speed of the particle would be minimum is equal to -



(A) $\frac{mv_o}{qE}$ (B) $\frac{mv_o\sin\theta}{qE}$

(C) $\frac{mv_o\cos\theta}{qE}$ (D) $\frac{2\pi m}{qB}$

Q32. There exists a uniform magnetic and electric field of magnitude 1 T and 1 V/m respectively along positive y–axis. A charged particle of mass 1 kg and of charge 1 C is having velocity 1 m/s along x–axis and is at origin at t = 0. Then the co–ordinates of particle at time π seconds will be -

(A) (0, 1, 2) (B) $(0, -\pi^2/2, -2)$

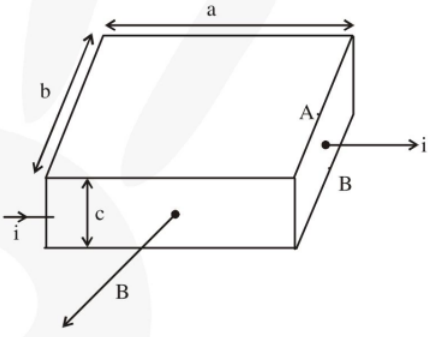
(C) $(2, \pi^2/2, 2)$ (D) $(0, \pi^2/2, 2)$

Q33. An electron having kinetic energy T is moving in a circular orbit of radius R perpendicular to a uniform magnetic induction $\vec{B}$. If kinetic energy is doubled and magnetic induction tripled, the radius will become

(A) $\frac{3R}{2}$ (B) $\sqrt{\frac{3}{2}}R$

(C) $\sqrt{\frac{2}{9}}R$ (D) $\sqrt{\frac{4}{3}}R$

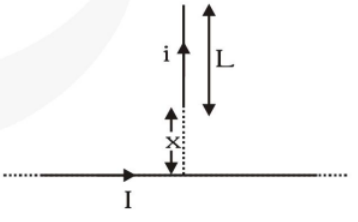
Q34. A current flows through a rectangular conductor in the presence of uniform magnetic field B pointing out of the page as shown. Then the potential difference $V_B - V_A$ is equal to (Assume charge carries in the conductor to be positively charged **moving with speed v**)



(A) Bvc (B) –Bvc

(C) Bvb (D) –Bvb

Q35. The magnetic force between wires as shown in figure is :-



(A) $\frac{\mu_0 iI^2}{2\pi}\ell n\left(\frac{x+\ell}{2x}\right)$

(B) $\frac{\mu_0 iI^2}{2\pi}\ell n\left(\frac{2x+\ell}{2x}\right)$

(C) $\frac{\mu_0 iI}{2\pi}\ell n\left(\frac{x+\ell}{x}\right)$

(D) None of these

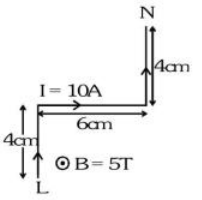
Q36. A wire 'LN' bent as shown in figure is placed in uniform perpendicular magnetic field of 5T. A 10A current flows through the wire. Magnetic force experienced by wire is :-

(A) 5 N

(B) 10 N

(C) 2.5 N

(D) 1.25 N



Q37. A solenoid 60 cm long and of radius 4.0 cm has 3 layers of windings of 300 turns each. A 2.0 cm long wire of mass 2.5 g lies inside the solenoid (near its centre) normal to its axis ; both the wire and the axis of the solenoid are in the horizontal plane. The wire is connected through two leads parallel to the axis of the solenoid to an external battery which supplies a current of 6.0 A in the wire. What value of current (with appropriate sense of circulation) in the windings of the solenoid can support the weight of the wire ? $g = 9.8\ ms^{-2}$.

(A) zero (B) 108 A

(C) 200 A (D) 458 A

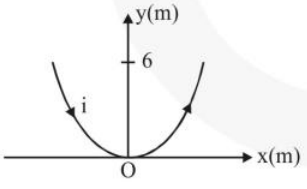
Q38. A wire is bent as a parabolic curve and kept in the x-y plane. The curve can be described by the equation $x^2 = 6y$. The wire carries a current i = 2A. If a uniform magnetic field $\vec{B} = 2\times10^{-3}\hat{k}$ tesla is applied, force experienced by the wire is nearly :-

(A) 1.5 $\hat{j}$N

(B) –1.5 $\hat{j}$N

(C) –0.05 $\hat{j}$N

(D) 2.5 $\hat{j}$N



Q39. A ring like metallic conductor of resistance R and radius a, caries a constant current I. The ratio of the angular momentum L of the conduction electrons (about the axis of the ring) and the magnetic field B at the centre of the ring satisfy [where e and m represent the magnitudes of the electronic charge and mass]

(A) $\frac{B}{L} \propto \frac{e^2}{m}$ (B) $\frac{B}{L} \propto e.m$

(C) $\frac{B}{L} \propto \frac{e}{m}$ (D) $\frac{B}{L} \propto \frac{m}{e}$

Q40. A charge of 3.14×10^{-6} C is distributed uniformly over a circular ring of radius 20.0 cm. The ring rotates about its axis with an angular velocity of 60.0 rad/s. Find the ratio of the electric field to the magnetic field at a point on the axis at a distance of 5.00 cm from the centre.

(A) zero (B) 0.5×10^{15} m/s

(C) 1.88×10^{15} m/s (D) 5.88×10^{15} m/s

Q41. Due to the flow of current in a circular loop of radius R, the magnetic field produced at the centre of the loop is B. The magnetic moment of the loop is :-

(A) $BR^3/2\ \pi\mu_0$ (B) $2\pi\ BR^3/\mu_0$

(C) $BR^2/2\pi\mu_0$ (D) $2\pi\ BR^2/\mu_0$

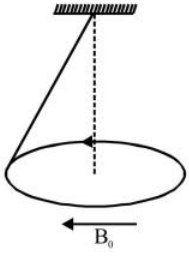
Q42. A uniform current carrying ring of mass m and radius R is connected by a massless string as shown. A uniform magnetic field B_0 exist in the region to keep the ring in horizontal position, then the current in the ring is (ℓ = length of string)

(A) $\frac{mg}{\pi RB_0}$

(B) $\frac{mg}{RB_0}$

(C) $\frac{mg}{3\pi RB_0}$

(D) $\frac{mg\ell}{\pi R^2 B_0}$



Q43. A solenoid of length 0.4 m, having 500 turns and 3A current flows through it. A coil of radius 0.01 m and have 10 turns and carries current of 0.4 A has to placed such that its axis is perpendicular to the axis of solenoid, then torque on coil will be:-

(A) 5.92×10^{-6} N.m

(B) 5.92×10^{-5} N.m

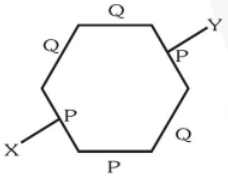
(C) 5.92×10^{-4} N.m

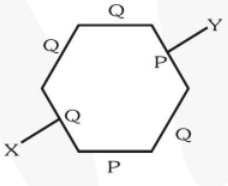
(D) 0.592×10^{-3} N.m

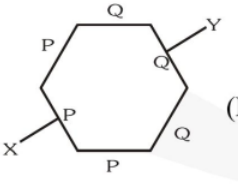
ONE OR MORE THAN ONE CORRECT TYPE

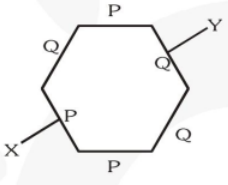
*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. In the following hexagons, made up of two different material P and Q, current enters and leaves from points X and Y respectively. In which case the magnetic field at its centre is not zero

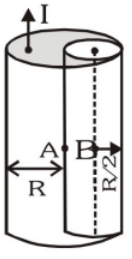
(A) 

(B) 

(C) 

(D) 

Q2. From a cylinder of radius R, a cylinder of radius R/2 is removed, as shown. Current flowing in the remaining cylinder is I. Magnetic field strength is -



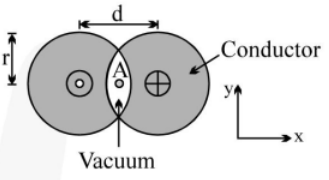
(A) zero at point A

(B) zero at point B

(C) $\frac{\mu_0 I}{3\pi R}$ at point A

(D) $\frac{\mu_0 I}{3\pi R}$ at point B

Q3. Two long conductors are arranged as shown above to form overlapping cylinders, each of radius r, whose centers are separated by a distance d. Current of density J flows into the plane of the page along the shaded part of one conductor and an equal current flows out of the plane of the page along the shaded portion of the other, as shown. What are the magnitude and direction of the magnetic field at point A?



(A) $(\mu_0/2\pi)\pi dJ$, in the +y-direction

(B) $(\mu_0/2\pi)d^2/r$, in the +y-direction

(C) $(\mu_0/2\pi)4d^2J/r$, in the –y-direction

(D) $(\mu_0/2\pi)Jr^2/d$, in the –y-direction

Q4. A charged particle is projected in a magnetic field $\vec{B} = 10\hat{k}$ T from the origin in x-y plane. The particle moves in a circle and just touches a straight line y = 5 (m) at point $\left(5\sqrt{3}, 5\right)$ (m). Then

(mass of particle = 5×10^{-5} kg, charge = 1 μC)

(A) The particle is projected at an angle 60° with x–axis

(B) The radius of the circle is 10 m

(C) The speed of the particle is 2m/s

(D) The speed of the particle is $5\sqrt{3}$ m/s

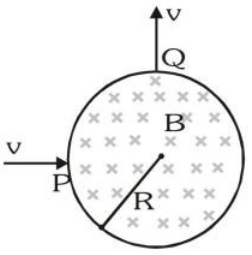
Q5. A particle of charge 'q' and mass 'm' enters normally (at point P) in a region of magnetic field with speed v. It comes out normally from Q after time T as shown in figure. The magnetic field B is present only in the region of radius R and is uniform. Initial and final velocities are along radial direction and they are perpendicular to each other. For this to happen, which of the following expression(s) is/are correct :-

(A) $B = \frac{mv}{qR}$

(B) $T = \frac{\pi R}{2v}$

(C) $T = \frac{\pi m}{2qB}$

(D) None of these



Q6. Which of the following statement is correct?

(A) A charge particle enters a region of uniform magnetic field at an angle 85° to magnetic lines of force. The path of the particle is a circle.

(B) An electron and a proton are moving with the same kinetic energy along the same direction. When they pass through uniform magnetic field perpendicular to their direction of motion, they describe circular path.

(C) There is no change in the energy of a charged particle moving in a magnetic field although magnetic force acts on it.

(D) Two electrons enter with the same speed but in opposite direction in a uniform transverse magnetic field. Then the two describe circle of the same radius and these move in the same direction.

Q7. A particle of mass m and charge q moving with velocity $\vec{v}$ enters a region of uniform magnetic field of induction $\vec{B}$. Then -

(A) its path in the region of the field is always circular

(B) its path in the region of the field is circular if $\vec{v}.\vec{B} = 0$

(C) its path in the region of the field is a straight line if $\vec{v} \times \vec{B} = 0$

(D) distance travelled by the particle in time T does not depend on the angle between $\vec{v}$ and $\vec{B}$

Q8. Two identical charged particles enter a uniform magnetic field with same speed but at angles 30° and 60° with field. Let a, b and c be the ratio of their time periods, radii and pitches of the helical paths than -

(A) abc =1 (B) abc >1

(C) abc <1 (D) a = bc

Q9. A particle of charge q and mass m starts moving from the origin under the action of an electric field $\vec{E} = E_0\hat{i}$ and magnetic field $\vec{B} = B_0\hat{i}$ with velocity $\vec{v} = v_0\hat{j}$. The speed of the particle will become $2v_0$ after a time

(A) $t = \frac{2mv_0}{qE_0}$ (B) $t = \frac{2Bq}{mv_0}$

(C) $t = \frac{\sqrt{3}\,Bq}{mv_0}$ (D) $t = \frac{\sqrt{3}\,mv_0}{qE_0}$

Q10. A particle of charge q and velocity v passes undeflected through a space with non–zero electric field E and magnetic field B. The undeflecting conditions will hold if

(A) signs of both q and E are reversed

(B) signs of both q and B are reversed

(C) both B and E are changed in magnitude, but keeping the product of $|B|$ and $|E|$ fixed.

(D) both B and E are doubled in magnitude

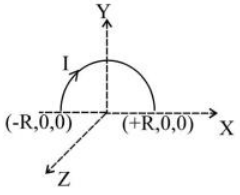
Q11. A semi circular current carrying wire having radius R is placed in x-y plane with its centre at origin 'O'. There is non-uniform magnetic field $\vec{B} = \frac{B_0 x}{2R}\hat{k}$ (here B_0 is +ve constant) is existing in the region. The magnetic force acting on semi circular wire will be along :

(A) – x-axis

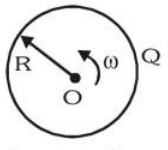
(B) + y-axis

(C) – y-axis

(D) + x-axis



Q12. A nonconducting disc having uniform positive charge Q, is rotating about its axis with uniform angular velocity ω. The magnetic field at the centre of the disc is–



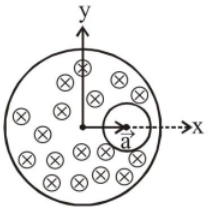
(A) directed outward

(B) having magnitude $\frac{\mu_0 Q\omega}{4\pi R}$

(C) directed inwards

(D) having magnitude $\frac{\mu_0 Q\omega}{2\pi R}$

Q13. Figure shows cross-section view of a infinite cylindrical wire with a cylinderical cavity, current density is uniform $\vec{J} = -j_0\hat{k}$ as shown in figure.



(A) Field inside cavity is uniform

(B) Field inside cavity is along $\vec{a}$

(C) Field inside cavity is perpendicular to $\vec{a}$

(D) If an electron is projected with velocity $v_0\hat{j}$ it will move undeviated before colliding with cavity wall.

Q14. A coil having N turns is wound tightly in the form of a spiral with inner and outer radii a and b respectively. When a current I passes through the coil, the magnetic field at the centre is :

(A) $\frac{\mu_0 NI}{b}$ (B) $\frac{2\mu_0 NI}{a}$

(C) $\frac{\mu_0 NI}{2(b-a)}\ell n\frac{b}{a}$ (D) $\frac{\mu_0 I^N}{2(b-a)}\ell n\frac{b}{a}$

Q15. A particle of specific charge (q/m) is projected from the origin of coordinates with initial velocity $[u\hat{i} - v\hat{j}]$. Uniform electric, magnetic fields exist in the region along the +y direction, of magnitude E and B. The particle will definitely return to the origin once if

(A) $[vB/2\pi E]$ is an integer

(B) $(u^2 + v^2)^{1/2}\ [B/\pi E]$ is an integer

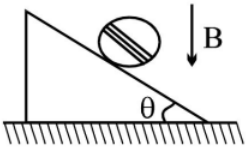
(C) $[vB/\pi E]$ is an integer

(D) $[uB/\pi E]$ is an integer

Q16. A metal ring of radius r = 0.5 m with its plane normal to a uniform magnetic field B of induction 0.2 T carries a current I = 100 A. The tension in newtons developed in the ring is:

(A) 100 (B) 50 (C) 25 (D) 10

Q17. In the figure shown a coil of single turn is wound on a sphere of radius R and mass m. The plane of the coil is parallel to the plane and lies in the equatorial plane of the sphere. Current in the coil is i. The value of B if the sphere is in equilibrium is -



(A) $\frac{mg\cos\theta}{\pi iR}$ (B) $\frac{mg}{\pi iR}$

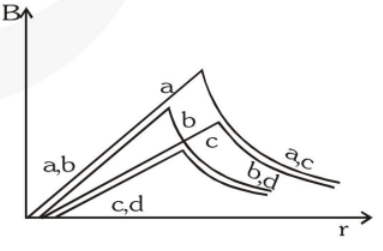
(C) $\frac{mg\tan\theta}{\pi iR}$ (D) $\frac{mg\sin\theta}{\pi iR}$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Questions no. 18 to 20

Curves in the graph shown give, as functions of radial distance r, the magnitude B of the magnetic field inside and outside four long wires a, b, c and d, carrying currents that are uniformly distributed across the cross–sections of the wires. Overlapping portions of the plots are indicated by double labels.



Q18. Which wire has the greatest radius?

(A) a (B) b (C) c (D) d

Q19. Which wire has the greatest magnitude of the magnetic field on the surface?

(A) a (B) b (C) c (D) d

Q20. The current density in wire a is–

(A) greater than in wire c

(B) less than in wire c

(C) equal to that in wire c

(D) not comparable to that of in wire c due to lack of information

Paragraph for Question No. 21 to 24

In uniform magnetic field, if angle between $\vec{v}$ and $\vec{B}$ is $0° < \theta < 90°$, path of the particle is helix, with its axis parallel to $\vec{B}$ and plane perpendicular to $\vec{B}$. Here $\vec{v}$ is the velocity vector of the particle and $\vec{B}$ magnetic field vector. Let v_1 be the component of $\vec{v}$ along $\vec{B}$ and v_2 the component perpendicular to $\vec{B}$. Suppose p is the pitch, T the time period and r the radius of helix.

Then : $T = \frac{2\pi m}{Bq}$, $r = \frac{mv_2}{Bq}$ and $p = (v_1)\,(T)$.

A charged particle (q, m) is released from origin with velocity $\vec{v} = v_0\hat{i}$ in a uniform magnetic field $\vec{B} = \frac{B_0}{2}\hat{i} + \frac{\sqrt{3}B_0}{2}\hat{j}$.

Q21. Pitch of the helical path described by the particle is :

(A) $\frac{2\pi m v_0}{B_0 q}$

(B) $\frac{\sqrt{3}\pi m v_0}{2B_0 q}$

(C) $\frac{\pi m v_0}{B_0 q}$

(D) $\frac{2\sqrt{3}\pi m v_0}{B_0 q}$

Q22. z–component of velocity is $\frac{\sqrt{3}v_0}{2}$ after time t = ...

(A) $\frac{2\pi m}{B_0 q}$ (B) $\frac{\pi m}{B_0 q}$

(C) $\frac{\pi m}{2B_0 q}$ (D) $\frac{2\pi m}{4B_0 q}$

Q23. Maximum z–coordinate of the particle is :

(A) $\frac{\sqrt{3}mv_0}{B_0 q}$ (B) $\frac{2\sqrt{3}mv_0}{B_0 q}$

(C) $\frac{2mv_0}{B_0 q}$ (D) $\frac{mv_0}{B_0 q}$

Q24. When z–coordinate has its maximum value :

(A) $v_x = 0$

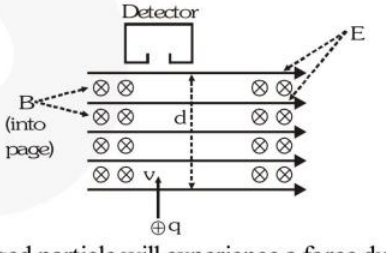
(B) $v_y = 0$

(C) Both (A) and (B) are correct

(D) Both (A) and (B) are wrong

Paragraph for Questions no. 25 to 28

A velocity filter uses the properties of electric and magnetic fields to select charged particles that are moving with a specific velocity. Charged particles with varying speeds are directed into the filter as shown in figure. The filter consists of an electric field E and a magnetic field B, each of constant magnitude, directed perpendicular to each other as shown. The particles that move straight through the filter with their direction unaltered by the fields have the specific filter speed, v_0. Those with speeds to v_0 may experience sufficiently little deflection that they also enter the detector.



The charged particle will experience a force due to the electric field given by the relationship $\vec{F} = q\vec{E}$, where q is the charge of the particle and $\vec{E}$ is the electric field. The moving particle will also experience a force due to the magnetic field. This force acts to oppose the force due to the electric field. The strength of the force due to the magnetic field is given by the relationship $\vec{F} = q(\vec{v} \times \vec{B})$, where q is the charge of the particle, $\vec{v}$ is the speed of the particle, and $\vec{B}$ is the magnetic field strength. When the forces due to the two fields are equal and opposite, the net force on the particle will be zero, and the particle will pass through the filter with its path unaltered. The electric and magnetic field strengths can be adjusted to choose the specific velocity to be filtered.

All mic. The effects of gravity can be neglected.

Q25. The electric and magnetic fields in the filter of figure are adjusted to detect particles with positive charge q of a certain speed, v_0. Which of the following expressions is equal to this speed ?

(A) $B/(q^2E)$ (B) $E/(q^2B)$

(C) B/E (D) E/B

Q26. Which of the following is true about the velocity filter shown in figure ?

(A) It would not work with negatively charged particles.

(B) The wider the detector entrance, the more narrow the range of speed detected.

(C) The greater the distance d, the more narrow the range of speeds detected.

(D) The detector may not detect a charged particle with the desired filter speed if its charge is too high.

Q27. Which of the following statements is true regarding a charged particle that is moving through the filter at a speed that is less than the filter speed ?

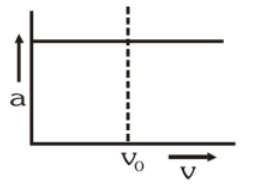
(A) It experiences a greater force due to the magnetic field than due to the electric field.

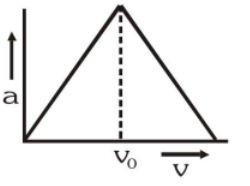
(B) It experiences a greater force due to the electric field than due to the magnetic field.

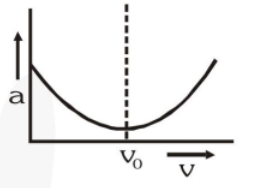
(C) It experiences equal force due to both fields but greater acceleration due to the electric field.

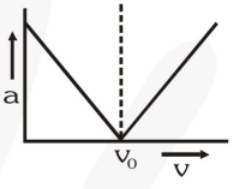
(D) It experiences equal force due to both fields but greater acceleration due to the magnetic field.

Q28. Particles of identical mass and charge are sent through the filter at varying speeds, and the magnitude of acceleration of each particle is recorded as it first begins to be deflected. If the filter is set to detect particles of speed v_0, which one of the following is correct graph between acceleration and velocity of particle:

(A)


(B)


(C)


(D)


Paragraph for Question No. 29 to 32

There are two infinite parallel current carrying wire in vertical plane. Lower wire is fixed and upper wire is having a linear mass density λ. Two wires are carrying current I_1 and I_2. Now upper wire is placed in a magnetic field produced by lower wire. Magnetic field due to lower wire at the location of upper wire is $\frac{\mu_0 I}{2\pi d}$ where $I_1 \rightarrow$ current in lower wire, $d \rightarrow$ separation between wire. Force on any small portion of upper wire having length $d\ell$ is $dF = \frac{\mu_0 I_1 I_2 d\ell}{2\pi d}$ where $I_2 \rightarrow$ current in the upper wire. If directions of current in the wires are appropriate then upper wire can be in equilibrium if its weight is balanced by magnetic force. Now answer the following questions

Q29. Equilibrium separation between the two wires is

(A) $\frac{\mu_0 I_1 I_2}{4\pi\lambda g}$ (B) $\frac{\mu_0 I_1 I_2}{2\pi\lambda g}$

(C) $\frac{\mu_0 I}{\pi\lambda g}$ (D) None of these

Q30. The upper wire can be in equilibrium if
(A) Direction of current in both wires is same
(B) Direction of current in both wires is opposite
(C) Equilibrium does not depend upon the direction of currents
(D) None of these

Q31. If upper wire is slightly displaced from its mean position and released, it will perform simple harmonic motion. As wire moves the total mechanical energy of wire.
(A) Remains constant
(B) Changes
(C) We can't say anything about mechanical energy in magnetic field
(D) None of the above

Q32. Consider wire at lower extreme position and upper extreme position. Kinetic energy of wire is zero at both the position then -
(A) Gravitational potential energy is also same at both positions
(B) Gravitation potential energy is different at both positions
(C) Gravitational potential energy change can be neglected because displacement of wire from the mean position is very small
(D) None of the above

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q33. A charged particle with some initial velocity is projected in a region where uniform electric and/or magnetic fields are present. In Column-I information about the existence of electric and/or magnetic field and direction of initial velocity of charged particle are given, while in column II the possible paths of charged particle is mentioned. Match the entries of Column I with the entries of Column II.

Column–I	**Column–II**
(A) $\vec{E}=0, \vec{B}\neq 0$ and initial velocity is at an unknown angle with $\vec{B}$	(p) Straight line
(B) $\vec{E}\neq 0, \vec{B}=0$ and initial velocity is at an unknown angle with $\vec{E}$	(q) Parabola
(C) $\vec{E}\neq 0, \vec{B}\neq 0, \vec{E}\parallel\vec{B}$ and initial velocity is perpendicular to $\vec{E}$	(r) Circular
(D) $\vec{E}\neq\vec{B}, B\neq 0, \vec{E}$ perpendicular $\vec{B}$ and initial velocity is perpendicular to both $\vec{E}$ and $\vec{B}$	(s) Helical path with nonuniform pitch (t) Helical path with uniform pitch

Q34. **Column I** (Magnetic moment of) **Column II**

(A) a uniformly charged ring rotating uniformly about its axis (p) $\frac{q\omega r^2}{5}$

(B) a charged particle rotating uniformly about a point (q) $\frac{q\omega r^2}{4}$

(C) a uniformly charged disk rotating uniformly about its axis (r) $\frac{q\omega r^2}{3}$

(D) a uniformly charged spherical shell rotating uniformly about one of its diameter (s) $\frac{q\omega r^2}{2}$

(E) a uniformly charged sphere rotating uniformly about one of its diameter (t) $q\omega r^2$

Answer Key

Ex-1

1	2	3	4	5	6	7	8	9	10
B	B	B	B	B	B	D	A	A	C
11	12	13	14	15	16	17	18	19	20
B	D	D	D	C	A	B	C	B	A
21	22	23	24	25	26	27	28	29	30
C	C	C	A	B	C	D	B	A	A
31	32	33							
C	A	D							

Ex-1A

1. B,C **2.** B,D **3.** A,B,C **4.** A,B,C **5.** A,B,C

6. A,B **7.** A,B,C **8.** C **9.** A

10. A → q,s ; B → p,s ; C → q,s ; D → p,s

11. A → r ; B → q ; C → s

12. A → q ; B → p,q ; C → p,q,r

13. 1.2 cm, 4.35 cm **14.** (a) $\frac{\mu_0 I}{4R}\otimes$ (b) $\frac{\mu_0 I}{8R}\otimes$

15. $\mu_0 nI$ **16.** $\sqrt{2}M$

Ex-2									
1	2	3	4	5	6	7	8	9	10
A	B	D	D	A	C	B	D	A	C
11	12	13	14	15	16	17	18	19	20
D	C	C	D	B	C	A	A	A	C
21	22	23	24	25	26	27	28	29	30
D	A	D	B	C	C	D	B	D	B
31	32	33	34	35	36	37	38	39	40
B	D	C	A	C	A	B	C	C	C
41	42	43							
B	A	A							

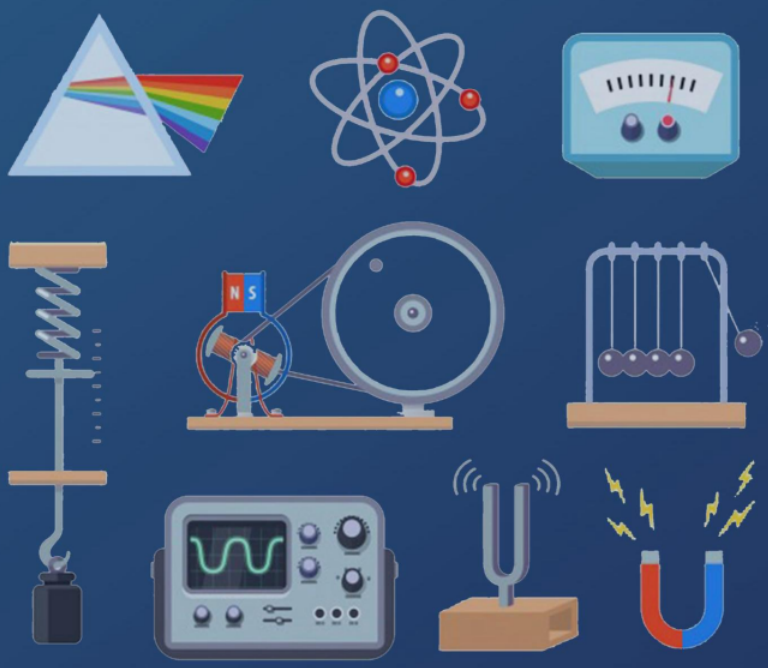
Ex-2A

1. A,B **2.** C,D **3.** A **4.** A **5.** A,B,C
6. B,C **7.** B,C,D **8.** A,D **9.** D **10.** D
11. A **12.** A,D **13.** A,C,D **14.** C **15.** C
16. D **17.** B **18.** C **19.** A **20.** A
21. C **22.** C **23.** A **24.** D **25.** D
26. C **27.** B **28.** D **29.** B **30.** B
31. B **32.** B
33. (A) $\rightarrow$ (p,r, t) ; (B) $\rightarrow$ (p,q) ; (C) $\rightarrow$ (s) ; (D) $\rightarrow$ (p)
34. A $\rightarrow$ s ; B $\rightarrow$ s ; C $\rightarrow$ q ; D $\rightarrow$ r ; E $\rightarrow$ p

-: Important Notes & Formulas :-

PHYSICS

Magnetism & Matter



SHEET

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Contents

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2.	Homework Index	Page - iii
3.	Exercise 1	Page - 1
4.	Exercise 2	Page - 3
5.	Answer Key	Page - 5

Note

Detailed solutions are available on the eSaral App.

Module Description

For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-2
1	Introduction to magnetism	1	
2	The bar magnet	2	1
3	The electrostatic analog	3	2,3
4	Bar magnet as an equivalent solenoid	4	
5	Dipole in uniform magnetic field	5-7	4-7
6	Magnetism and gauss's law		
7	Earth's Magnetism	8-10	8-11
8	Why do magnets attract and repel?		
9	Magnetism and magnetic intensity	11-13	12
10	Diamagnetism, paramagnetism and ferromagnetism	14-18	13
11	Hysteresis	19,20	14,15

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Introduction to Magnetism

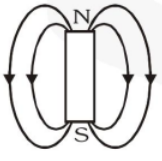
Q1. The geometric length of a bar magnet is 24 cm. The length of the magnet is -

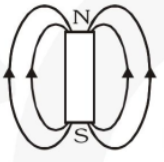
(A) 24cm (B) 28.8cm

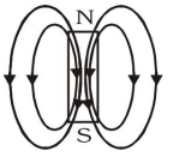
(C) 20cm (D) 30cm

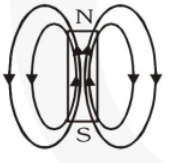
The bar magnet

Q2. The magnetic field lines due to a bar magnet are correct shown in :

(A) 

(B) 

(C) 

(D) 

The electrostatic analog

Q3. The magnetic moment of a short magnet is 8 Am^2 The magnetic induction at a point 20cm away from its mid point on (i) axial point (ii) equatorial point respectively, will be :–

(A) 2×10^{-4} and 10^{-4} T

(B) 3×10^{-4} and 2×10^{-4} T

(C) 4×10^{-4} and 3×10^{-4} T

(D) none of these

Bar magnet as an equivalent solenoid

Q4. A solenoid has 10^3 turns per unit length. On passing a current of 2A, magnetic induction is measured to be 4π Wb/m^2. Calculate magnetic susceptibility of core.

(A) 5000 (B) 4999

(C) 2500 (D) 2499

Dipole in uniform magnetic field

Q5. At two places A and B using vibration magnetometer, a magnet vibrates in a horizontal plane and its respective periodic time 2 sec and 3 sec and at these places the earths horizontal components are B_A and B_B respectively. Then the ratio between B_A and B_B will be :-

(A) 9 : 4 (B) 3 : 2

(C) 4 : 9 (D) 2 : 3

Q6. A magnet of magnetic moment 4A–m^2 is held in a uniform magnetic field 5×10^{-4}T with the magnetic moment vector makes an angle 30° with the field. Work done in increasing the angle from 30° to 45°:-

(A) 3.2×10^{-4} J

(B) 1.6×10^{-4} J

(C) 1.6×10^{-3} J

(D) 3.2×10^{-3} J

Q7. A bar magnet has a magnetic moment equal to 5×10^{-5} A-m^2. It is supended in a magnetic field which has a magnetic induction B equal to $8\pi \times 10^{-4}$ Tesla. The magnet vibrates with a period of vibration equal to 15 sec. The moment of inertia of the magnet is -

(A) 5.2×10^{-7} kg-m^2

(B) 11.25×10^{-7} kg-m^2

(C) 22.5×10^{-7} kg-m^2

(D) 7.16×10^{-7} kg-m^2

Earth's Magnetism

Q8. At a certain place, the horizontal component B_0 and the vertical component V_0 of the earth's magnetic field are equal in magnitude. The total intensity at the place will be :

(A) B_0 (B) B_0^2

(C) $2B_0$ (D) $\sqrt{2}\,B_0$

Q9. At Geo-magnetic poles, the angle of dip is:-

(A) 45° (B) 30°

(C) zero (D) 90°

Q10. The vertical component of earth magnetic field is zero at or the earth's magnetic field always has a vertical component except at the :-

(A) magnetic poles

(B) geographical poles

(C) every place

(D) magnetic equator

Magnetism and magnetic intensity

Q11. Using mass (M), length (L), time (T) and current (A) as fundamental quantities, the dimension of permeability is :-

(A) $[M^{-1}LT^{-2}A]$ (B) $[ML^2T^{-2}A^{-1}]$

(C) $[MLT^{-2}A^{-2}]$ (D) $[MLT^{-1}A^{-1}]$

Q12. The magnetic susceptibility of a para-magnetic substance is 3×10^{-4}. It is placed in a magnetising field of 4×10^4 A/m. The intensity of magnetisation will be :-

(A) 3×10^8 A/m (B) 12×10^8 A/m

(C) 12 A/m (D) 24 A/m

Q13. The magnetic moment of a magnet of mass 75 gm is 9×10^{-7} A-m^2. If the density of the material of magnet is 7.5×10^3 kg/m^3 then intensity of magnetisation will be :-

(A) 0.9 A/m (B) 0.09 A/m

(C) 9 A/m (D) 90 A/m

Diamagnetism, paramagnetism and ferromagnetism

Q14. Relative permittivity and permeability of a material are ε_r and μ_r, respectively. Which of the following values of these quantities are allowed for a diamagnetic material ?

(A) $\varepsilon_r = 0.5, \mu_r = 1.5$

(B) $\varepsilon_r = 1.5, \mu_r = 0.5$

(C) $\varepsilon_r = 0.5, \mu_r = 0.5$

(D) $\varepsilon_r = 1.5, \mu_r = 1.5$

Q15. The material of permanent magnet has :-

(A) High retentivity, low coercivity

(B) Low retentivity, high coercivity

(C) Low retentivity, low coercivity

(D) High retentivity, high coercivity

Q16. When a diamagnetic substances is inserted in a current carrying coil, then magnetic field is :-

(A) Decreased

(B) Unchanged

(C) Increased

(D) Increased or decreased depending upon the relative volume of the substance

Q17. The value of magnetic susceptibility for super–conductors is :-

(A) Zero (B) Infinity

(C) +1 (D) –1

Q18. If the magnetic susceptibility of a magnetic material is – 0.004 then its nature will be :-

(A) Diamagnetic

(B) Paramagnetic

(C) Ferromagnetic

(D) Non magnetic

Hysteresis

Q19. Which of the following statements is incorrect about hystersis :-

(A) this effect is common to all ferrro-magnetic substances

(B) the hysteresis loop area is proportional to the thermal energy developed per unit volume of the material

(C) the hysteresis loop area is independent of the thermal energy developed per unit volume of the material

(D) the shape of the hysteresis loop is characterstic of the material

Q20. Soft iron is used to make the core of transformer, because of its :

(A) low coercivity and low retentivity

(B) low coercivity and high retentivity

(C) high coercivity and high retentivity

(D) high coercivity and low retentivity

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. The magnetic lines of force inside a bar magnet:

(A) are from north-pole to south-pole of the magnet

(B) do not exist

(C) depend upon the area of cross-section of the bar magnet

(D) are from south-pole to north-pole of the magnet

Q2. A bar magnet is held perpendicular to a uniform field. If the couple acting on the magnet is to be halved by rotating it, the angle by which it is to be rotated is :-

(A) 30° (B) 60° (C) 45° (D) 90°

Q3. The magnetic field at a point X on the axis of a small bar magnet is equal to the field at a point Y on the equator of the same magnet. The ratio of the distances of point X and Y from the centre of the magnet is:-

(A) 2^{-3} (B) $2^{-1/3}$ (C) 2^{3} (D) $2^{1/3}$

Q4. Magnetic moments of two identical bar magnets are M and 2M respectively. Both are combined in such a way that their simmilar poles are together. The time period in this situation is T_1. If polrity of one of the magnet is reversed then its period becomes T_2 then :-

(A) $T_1 > T_2$

(B) $T_1 < T_2$

(C) $T_1 = T_2$

(D) None of these

Q5. A magnetic needle is kept in a non-uniform magnetic field. It experiences-

(A) a torque but not a force

(B) neither a force nor a torque

(C) a force and a torque

(D) a force but not a torque

Q6. The time period of oscillation of a magnet in vibration magnetometer is 1.5 second. The time period of oscillation of another magnet similar in size, shape and mass but having one fourth magnetic moment that of the same place will be :-

(A) 0.75 s (B) 1.5s

(C) 3.0 s (D) 6.0 s

Q7. A magnetic needle is made to vibrate in uniform field B_H, then its time period is T. If it vibrates in the field of intensity $4B_H$, it time period will be :-

(A) 2T (B) $\frac{T}{2}$

(C) $\frac{2}{T}$ (D) T

Q8. The horizontal component of earth's magnetic field at place is $0.36x10^{-4}$ weber/m^2. If the angle of dip at that place is 60° then the value of vertical component of earth's magnetic field will be (in wb/m^2)

(A) $6x10^{-5}T$ (B) $6\sqrt{2}x10^{-5}T$

(C) $3.6\sqrt{3}\times10^{-5}T$ (D) $\sqrt{2}x10^{-5}T$

Q9. If the angle of dip at two places are 30° and 45° respectively, then the ratio of horizontal component of earth's magnetic field at two places will be :-

(A) $\sqrt{3}:\sqrt{2}$ (B) $1:\sqrt{2}$

(C) $1:\sqrt{3}$ (D) 1 : 2

Q10. A magnetic needle suspended horizontally by an unspun silk fibre, Oscillates in the horizontal plane because of the restoring torque originating mainly from :-

(A) the torsion of the silk fibre

(B) the force of gravity

(C) the horizontal component of earth's magnetic field

(D) all the above factors

Q11. The value of earth magnetic field $B_H = 0.3$ gauss. In this magnetic field a magnet is oscillating with 5 oscillation/min. To increase the oscillation of magnet upto 10 oscillation/min. The value of earth magnetic field increased by :-

(A) 0.3 gauss (B) 0.6 gauss

(C) 0.9 gauss (D) 0.12 gauss

Q12. If the magnet of length 10 cm and pole strength 40 Am is placed at an angle of 45° in an uniform induction field of intensity 2×10^{-4} tesla. The couple acting on it will be :-

(A) 0.656×10^{-5} N–m

(B) 0.656×10^{-4} N–m

(C) 0.5656×10^{-4} N–m

(D) 0.5656×10^{-3} N–m

Q13. Which of the following statements is correct for ferromagnetic material :-

(A) These become diamagnetic at Curie temperature

(B) These become paramagnetic at Curie temperature

(C) Their magnetic susceptibility becomes zero at Curie temperature

(D) Its magnetic perperties are explained on the basis of electron principle

Q14. The mass of a specimen of a ferromagnetic material is 0.6 kg. and its density is 7.8×10^3 kg/m^3. If the area of hysteresis loop of alternating magnetising field of frequency 50Hz is 0.722 MKS units then the hysteresis loss per second will be :-

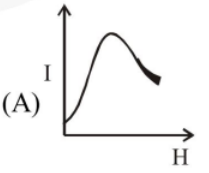
(A) 277.7×10^{-5} J/sec.

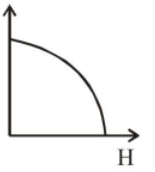
(B) 277.7×10^{-6} J/sec.

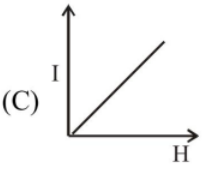
(C) 277.7×10^{-4} J/sec.

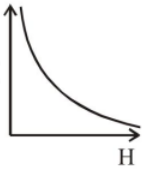
(D) 277.7×10^{-3} J/sec.

Q15. The correct I–H curve for paramagnetic materials is :-

(A) 

(B) 

(C) 

(D) 

Answer Key

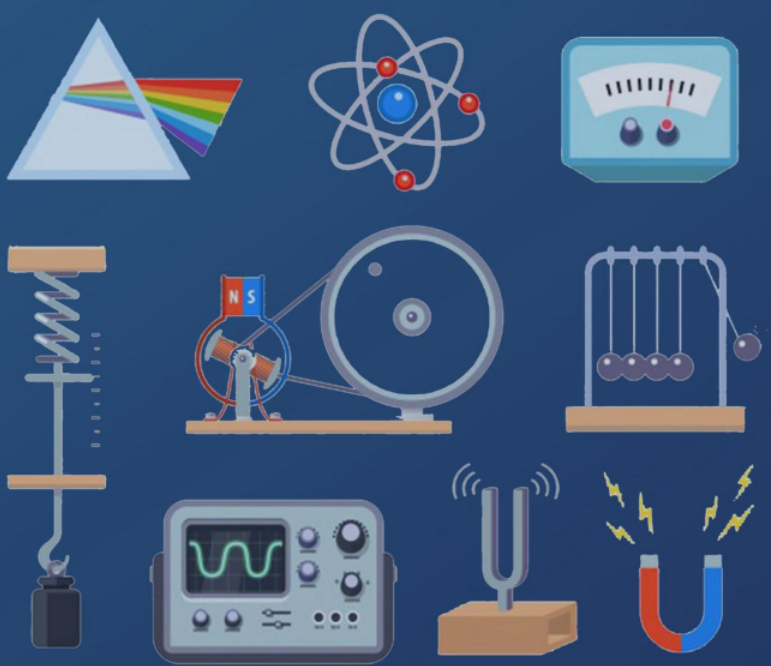
Ex - 1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	D	A	B	A	A	D	D	D	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	C	B	B	D	A	D	A	C	A

Ex - 2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	B	D	B	C	C	B	C	A	C
11	**12**	**13**	**14**	**15**					
C	D	B	A	C					

-: Important Notes & Formulas :-

PHYSICS

Newton Laws of Motion



SHEET

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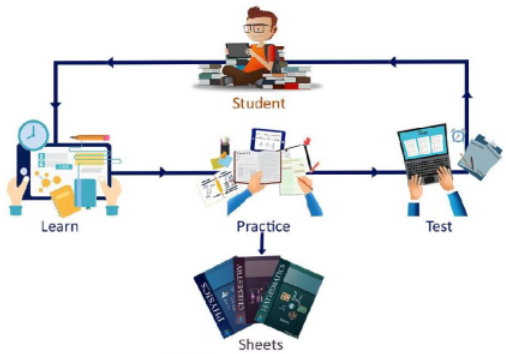
7.	Answer Key	Page - 15

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr. No.	Topic	Ex - 1	Ex - 1A	Ex - 2	Ex - 2A
1	Newton's Laws of Motion	1-3	1		
2	Different Types of Forces		2		
3	Translational Motion	4-8	3, 5, 4, 11	1, 2	6,7
4	Translational Equilibrium	9-14	6,9	3, 4, 5	
5	Pulley, Weighing Machine and Heavy String	15-18	7	6, 7, 8	1,2,8-11
6	Spring Force	19-23	12	9	3,12-17
7	Pseudo Force	24	10		
8	Constraint Motion	25-26	8	10,11,12	4
9	Wedge Constraint	27			5,18

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Newton's Laws of Motion

Q1. A man getting down a running bus, falls forward because-

(A) due to inertia of rest, road is left behind and man reaches forward

(B) due to inertia of motion upper part of body continues to be in motion in forward direction while feet come to rest as soon as they touch the road

(C) he leans forward as a matter of habit

(D) of the combined effect of all the three factors stated in (1), (2) and (3)

Q2. A vehicle of 100 kg is moving with a velocity of 5 m/sec. To stop it in $\frac{1}{10}$ s. The required force in opposite direction is-

(A) 5000 newton (B) 500 newton

(C) 50 newton (D) 1000 newton

Q3. Two astronauts A and B connected with a rope stay stationary in free space relative to their spaceship. Mass of A is more than that of B and the rope is straight. Astronaut A starts pulling the rope but astronaut B does not. If you were the third astronaut in the spaceship, what do you observe?

(A) Astronaut B accelerates towards A and A remains stationery.

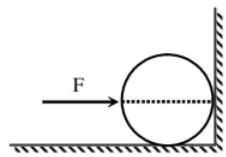
(B) Both accelerate towards each other with equal accelerations of equal modulus.

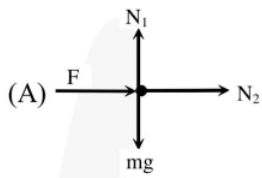
(C) Both accelerate towards each other but acceleration of B is greater than that of A.

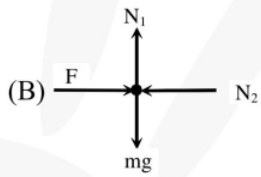
(D) Both accelerate towards each other but acceleration of B is smaller than that of A.

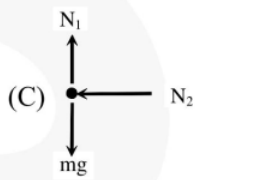
Translational Motion

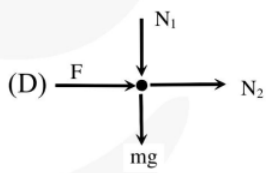
Q4. A ball of mass m kept at the corner as shown in the figure, is acted by a horizontal force F. The correct free body diagram of ball is -



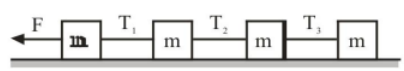
(A) 

(B) 

(C) 

(D) 

Q5. Four blocks of same mass connected by cords are pulled by force F on a smooth horizontal surface, as in figure. The tension T_1, T_2 and T_3 will be -



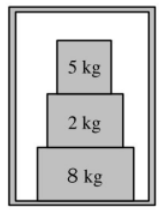
(A) $T_1 = F/4, T_2 = 3F/2, T_3 = F/4$

(B) $T_1 = F/4, T_2 = F/2, T_3 = F/2$

(C) $T_1 = 3F/4, T_2 = F/2, T_3 = F/4$

(D) $T_1 = 3F/4, T_2 = F/2, T_3 = F/2$

Q6. Three boxes are placed in a lift. When acceleration of the lift is 4 m/s^2, the net force on the 8 kg box is closest to



(A) 80 N

(B) 48 N

(C) 40 N

(D) 32 N

Q7. A block of mass m is placed in contact with one end of a smooth tube of mass M (see figure). A horizontal force F acts on the tube in each case (i) and (ii). Then mark **incorrect** option :

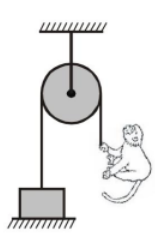
(A) $a_m = 0$ and $a_M = \frac{F}{M}$ in (i)

(B) $a_m = a_M = \frac{F}{M+m}$ in (i)

(C) $a_m = a_M = \frac{F}{M+m}$ in (ii)

(D) Net force on m is $\frac{mF}{M+m}$ in (ii)

Q8. A monkey weighing 10 kg is climbing up a light rope and frictionless pulley attached to 15 kg mass at other end as in figure. In order to raise the 15 kg mass off the ground the monkey must climb-up -



(A) with constant acceleration g/3.

(B) with an acceleration greater than g/2.

(C) with an acceleration greater than g/4.

(D) It is not possible because weight of monkey lesser than the block.

Translational Equilibrium

Q9. Under what condition(s) will an object be in equilibrium ?

(A) Only if it is at rest

(B) Only if it is moving with constant velocity

(C) Only if it is moving with constant acceleration

(D) If it is either at rest or moving with constant velocity

Q10. If the net force on a body is zero, will it definitely be at rest ?

(A) Yes

(B) Not necessary. Net force is zero on the body moving with accelerating velocity

(C) Not necessary. Net force is zero on the body moving with decelerating velocity

(D) Not necessary. This is possible that the body is moving with constant velocity

Q11. Ten coins are placed on top of each other on a horizontal table. If the mass of each coin is 10 gm and acceleration due to gravity is 10 m/s^2, what is the magnitude and direction of the normal force on the 7th coin applied by 8th coin (counted from the bottom) ?

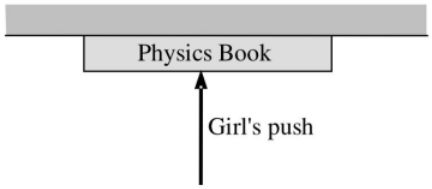
(A) 0.1 N vertically downwards

(B) 0.7 N vertically upwards

(C) 0.3 N vertically downwards

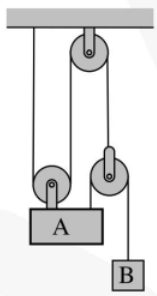
(D) 0.3 N vertically upwards

Q12. A girl pushes her physics book up against the horizontal ceiling of her room as shown in the figure. The book weighs 20 N and she pushes upwards with a force of 25 N. The choices below list the magnitudes of the contact force F_{CB} between the ceiling and the book, and F_{BH} between the book and her hand. Select the correct pair.



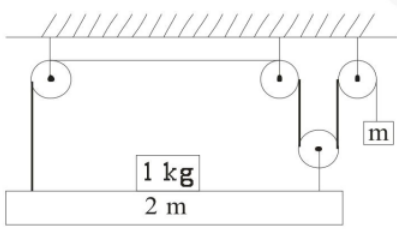
(A) $F_{CB} = 20$ N and $F_{BH} = 25$ N
(B) $F_{CB} = 25$ N and $F_{BH} = 45$ N
(C) $F_{CB} = 5$ N and $F_{BH} = 25$ N
(D) $F_{CB} = 5$ N and $F_{BH} = 45$ N

Q13. In arrangement shown the block A of mass 15 kg is supported in equilibrium by the block B. Mass of the block B is closest to



(A) 2 kg (B) 3 kg
(C) 4 kg (D) 5 kg

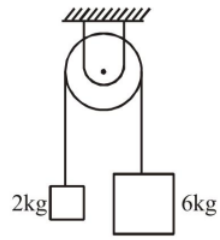
Q14. If the arrangement shown in the figure is in equilibrium, mass m of the block is closest to -



(A) 1.0 kg (B) 1.5 kg
(C) 3.0 kg (D) 6.0 kg

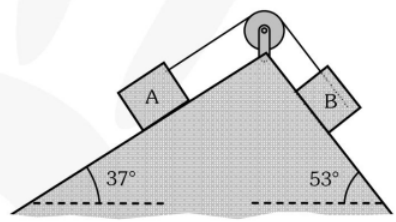
Pulley, Weighing Machine and Heavy String

Q15. Find acceleration of blocks :-



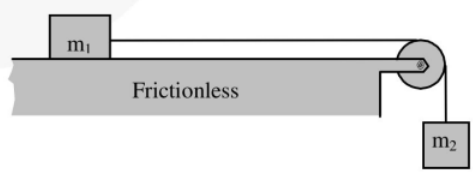
(A) g (B) g/2
(C) g/3 (D) g/4

Q16. The acceleration of the block A is 2 m/s^2 down the incline. The ratio of the mass of A to that of B is -



(A) 7 : 6 (B) 5 : 2
(C) 5 : 3 (D) 3 : 4

Q17. In the arrangement shown, the blocks of unequal masses are held at rest. When released, acceleration of the blocks is -



(A) g/2.
(B) g.
(C) a value between zero and g.
(D) a value that could be greater than g.

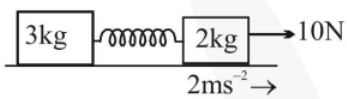
Q18. A man is standing on a weighing machine with a block in his hand. The machine records w. When he takes the block upwards with some acceleration the machine records w_1. When he takes the block down with same acceleration, the machine records w_2.Then choose correct option :

(A) $w_1 = w = w_2$ (B) $w_1 < w < w_2$

(C) $w_2 < w < w_1$ (D) $w_2 = w_1 > w$

Spring Force

Q19. Find the acceleration of 3 kg mass when acceleration of 2 kg mass is 2 ms^{-2} as shown in figure.



(A) 3 ms^{-2} (B) 2 ms^{-2}

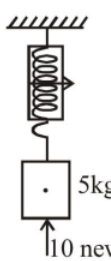
(C) 0.5 ms^{-2} (D) zero

Q20. An elastic spring of relaxed length ℓ_o and force constant k is cut into two parts of lengths ℓ_1 and ℓ_2. The force constants of these parts are respectively.

(A) $\frac{k\ell_o}{\ell_1}$ and $\frac{k\ell_o}{\ell_2}$ (B) $\frac{k\ell_1}{\ell_0}$ and $\frac{k\ell_2}{\ell_o}$

(C) $\frac{k\ell_0}{\ell_2}$ and $\frac{k\ell_0}{\ell_1}$ (D) $\frac{k\ell_2}{\ell_0}$ and $\frac{k\ell_1}{\ell_0}$

Q21. Reading of spring balance is (g = 10 m/s^2):-



(A) 1 kg wt (B) 2 kg wt

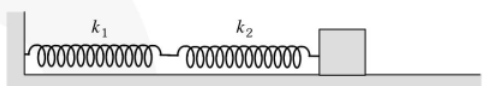
(C) 3 kg wt (D) 4 kg wt

Q22. A block of mass 4kg is suspended through two light spring balances A and B. Then A and B will read respectively :-

(A) 4 kg and zero kg (B) Zero kg and 4 kg

(C) 4 kg and 4 kg (D) 2 kg and 2 kg

Q23. The mass in the figure can slide on a frictionless surface. When the mass is pulled out, spring 1 is stretched a distance x_1 and spring 2 is stretched a distance x_2. The spring constants are k_1 and k_2 respectively. Magnitude of spring force pulling back on the mass is -



(A) k_1x_1

(B) $(k_1x_1 - k_2x_2)]$

(C) $(k_1x_1 + k_2x_2)$

(D) $0.5\ (k_1 + k_2)\ (x_1 + x_2)$

Pseudo Force

Q24. How much Pseudo force will act on a mass of 3 kg as observed from a reference frame of person of 5kg moving with acceleration of 2 m/s^2 in right direction?

(A) 10 N towards left

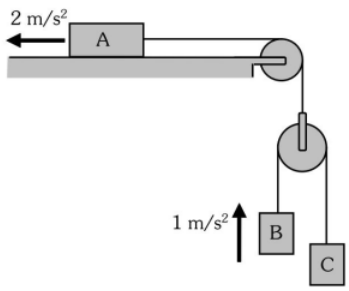
(B) 10 N towards right

(C) 6N towards right

(D) 6N towards left

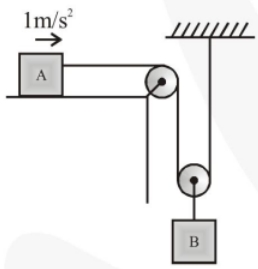
Constraint Motion

Q25. In the setup shown, find acceleration of the block C.



(A) 3 m/s² ↑ (B) 3 m/s² ↓
(C) 5 m/s² ↑ (D) 5 m/s² ↓

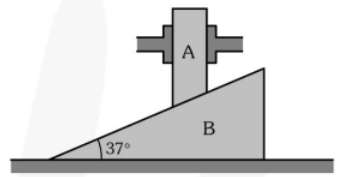
Q26. Find $\vec{a}_B$.



(A) 2 m/s² ↓ (B) $\frac{1}{2}$ m/s² ↑
(C) $\frac{1}{2}$ m/s² ↓ (D) 1 m/s² ↓

Wedge Constraint

Q27. Rod A can slide in vertical direction pushing the triangular wedge B towards left. The wedge is moving toward right with uniform acceleration 4 m/s². Acceleration of the rod A is:



(A) 8 m/s² (B) 4 m/s²
(C) 3 m/s² (D) 2 m/s²

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A particle stays at rest as seen from a frame. Which of the following statements is/are correct:-

(A) The frame is inertial

(B) The frame may be inertial but the resultant force on the particle is zero

(C) The frame may be non-inertial but there is a non-zero resultant force on the partick

(D) The frame is non-inertial

Q2. Consider a block suspended from a light string as shown in the figure. Which of the following pairs of forces constitute Newton's third law pair?

(A) Force with which string pulls on the ceiling and the force with which string pulls on block

(B) Force with which string pulls on the block and weight of the block

(C) Force acting on block due to the earth and force the block exerts on the earth

(D) Force with which block pulls on string and force with which the string pulls on the block

Q3. If a horizontal support exerts an upward force of 10 N on a block of weight 9.8 N placed on it, which of the following statements is/are correct. Assume acceleration due to gravity to be 9.8 m/s^2.

(A) The block exerts a force of 10 N on the support.

(B) The block exerts a force of 9.8 N on the support.

(C) The block has an upward acceleration.

(D) The block has a downward acceleration.

Q4. A man of mass m is on a ladder of mass M hanging from fixed support vertically. Choose the correct statement/statements about the situation.

(A) If the man climbs up the ladder with decreasing speed, force applied by ladder on the support is less than (m+M)g.

(B) If the man climbs up the ladder with uniform speed, force applied by ladder on the support is equal to (M+m)g.

(C) If the man climbs down the ladder with increasing speed, force applied by ladder on the support is more than (M+m)g.

(D) If the man climbs down the ladder with decreasing speed, force applied by ladder on the support is less than (M+m)g.

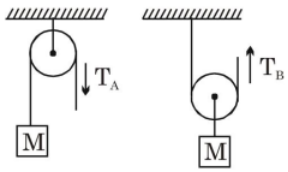
SUBJECTIVE TYPE

Q5. A force F applied to an object of mass m_1 produces an acceleration of 3.00 m/s^2. The same force applied to a second object of mass m_2 produces an acceleration of 1.00 m/s^2.

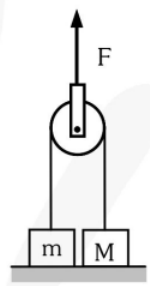
(i) What is the value of the ratio m_1 / m_2 ?

(ii) If m_1 and m_2 are combined, find their acceleration under the action of the force F.

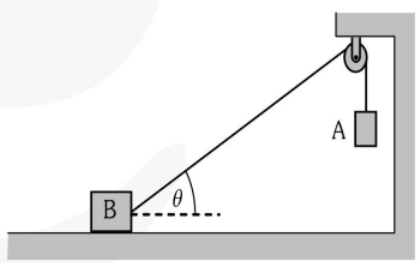
Q6. Consider the two configurations shown in equilibrium. Find ratio of T_A/T_B. (Ignore the mass of the rope and the pulley)



Q7. In the system shown, pulley and strings are ideal. The vertically upward pull F is being increased gradually, find magnitude of F and acceleration of the 5 kg block at the moment the 10 kg block leaves the floor. (m = 5 kg, M = 10 kg)



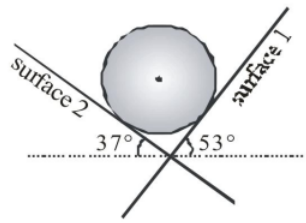
Q8. The block A is moving downward with constant velocity v_0. Find the velocity of the block B, when the string makes an angle θ with the horizontal.



MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q9. A sphere of mass 10 kg is placed in equilibrium in a V shaped groove plane made of two smooth surfaces 1 and 2 as shown in figure. ($g = 10\ ms^{-2}$)

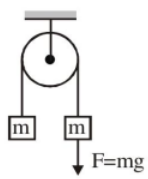
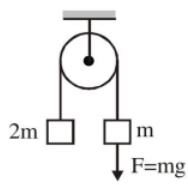
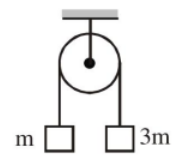


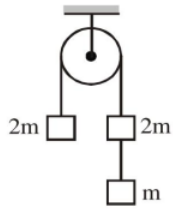
Column I	Column II
(A) Normal reaction by Surface 1	(P) Zero
(B) Normal reaction by surface 2	(Q) 60 N
(C) Force on sphere by Earth	(R) 80 N
(D) Net force on sphere	(S) 100 N
	(T) 120 N

Q10. Velocity of three particles A, B and C varies with time t as, $\vec{v}_A = (2t\hat{i} + 6\hat{j})m/s$; $\vec{v}_B = (3\hat{i} + 4\hat{j})m/s$ and $\vec{v}_C = (6\hat{i} - 4t\hat{j})$ m/s. Regarding the pseudo force match the following table :

Column I	Column II
(A) On A as observed by B	(P) Along positive x–direction
(B) On B as observed by C	(Q) Along negative x–direction
(C) On A as observed by C	(R) Along positive y–direction
(D) On C as observed by A	(S) Along negative y–direction
	(T) Zero

Q11. Match the situations in column I to the accelerations of blocks in the column II (acceleration due to gravity is g and F is an additional force applied to one of the blocks ?

Column I	Column II
(A) 	(P) $\frac{g}{5}$
(B) 	(Q) $\frac{g}{3}$
(C) 	(R) $\frac{g}{2}$

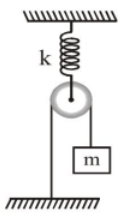
(D) 

(S) $\frac{2g}{3}$

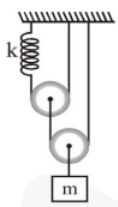
(T) zero

Q12. Find the extension in equilibrium in column-I and match them with column-II and choose the correct option from codes given belowl :

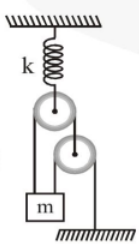
Column-I **Column-II**

(I) 

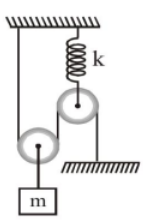
(P) $\frac{mg}{k}$

(II) 

(Q) $\frac{4mg}{3k}$

(III) 

(R) $\frac{2mg}{k}$

(IV) 

(S) $\frac{mg}{4k}$

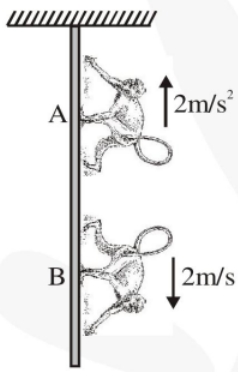
Codes :

	I	II	III	IV
(A)	R	Q	S	P
(B)	R	S	Q	P
(C)	P	R	S	Q
(D)	Q	P	R	S

SINGLE CORRECT TYPE

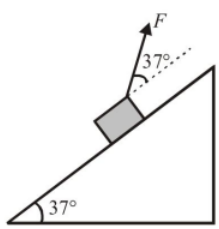
Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Two monkeys of masses 10 kg and 8 kg are moving along a vertical light rope, the former climbing up with an acceleration of 2 m/s^2, while the latter coming down with a uniform velocity of 2 m/s. Find tension in the rope at the fixed support.



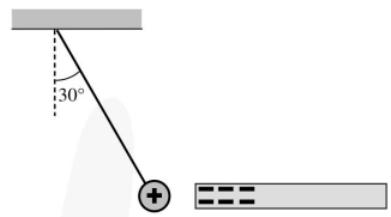
(A) 180 N (B) 200 N
(C) 80 N (D) 216 N

Q2. A block resting on a smooth inclined plane is acted upon by a force F as shown. If mass of block is 2 kg and F = 20 N and sin 37°= 3/5, the acceleration of block is -

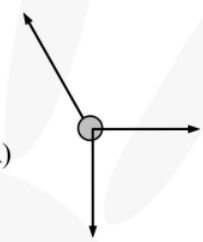


(A) 2 m/s^2 (B) 6 m/s^2
(C) 8 m/s^2 (D) zero

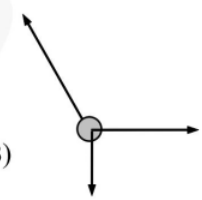
Q3. A small electrically charged sphere is suspended vertically from a thread. An oppositely charged rod is brought close to the sphere such that the sphere is in equilibrium displaced from the vertical by an angle of 30°. Which one of the following best represents the free body diagram for the sphere?



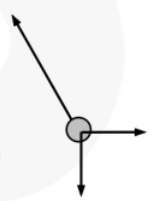
(A)



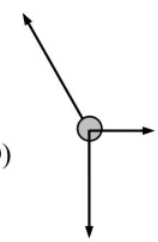
(B)



(C)



(D)

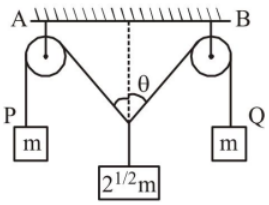


Q4. A flexible chain of weight W hangs between two fixed points A & B which are at the same horizontal level. The inclination of the chain with the horizontal at both the points of support is θ. What is the tension of the chain at the mid point?

(A) $\frac{W}{2}$. *cosec* θ (B) $\frac{W}{2}$. *tan* θ

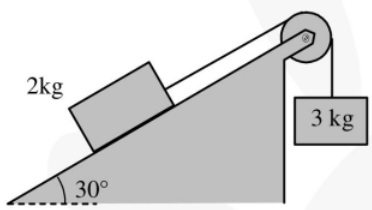
(C) $\frac{W}{2}$ *cot* θ (D) none

Q5. The pulleys and strings shown in the figure are smooth and of negligible mass. For the system to remain in equilibrium, the angle θ should be :



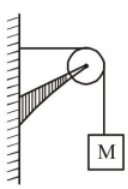
(A) 0° (B) 30°
(C) 45° (D) 60°

Q6. In the arrangement shown, the 2 kg block is held to keep the system at rest. The string and pulley are ideal. When the 2 kg block is set free, by what amount the tension in the string changes? [g = 10 m/s²]



(A) Increase of 12 N (B) Decrease of 12 N
(C) Increase of 18 N (D) Decrease of 18 N

Q7. A string of negligible mass going over a clamped pulley of mass *m* supports a block of mass *M* as shown in the figure. The force on the pulley by the clamp is given :



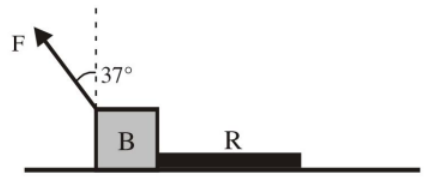
(A) $\sqrt{2}\,Mg$

(B) $\sqrt{2}\,mg$

(C) $\sqrt{(M+m)^2+m^2}\,g$

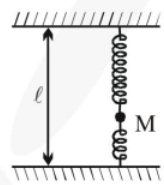
(D) $\sqrt{(M+m)^2+M^2}\,g$

Q8. A block B is tied to one end of a uniform rope R as shown. The mass of block is 2 kg and that of rope is 1 kg. A force F = 15 N is applied at angle 37° with vertical. The tension at the mid-point of rope is -



(A) 1.5 N (B) 2 N
(C) 3N (D) 4.5 N

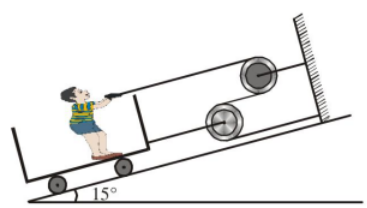
Q9. A small ball of mass M is held in equilibrium with two identical springs as shown in the figure. Force constant of each spring is k and relaxed length of each spring is $\ell/2$. What is distance between the ball and roof ?



(A) $\frac{\ell}{2}+\frac{Mg}{k}$ (B) $\frac{\ell}{2}-\frac{Mg}{k}$

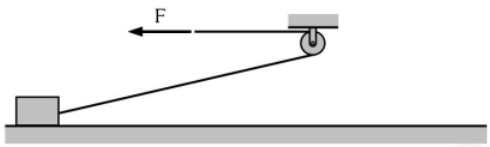
(C) $\frac{\ell}{2}+\frac{Mg}{2k}$ (D) $\frac{\ell}{2}-\frac{Mg}{2k}$

Q10. A trolley is being pulled up an incline plane by a man sitting on it (as shown in figure). He applies a force of 250 N. If the combined mass of the man and trolley is 100 kg, the acceleration of the trolley will be :
[sin15° = 0.26]



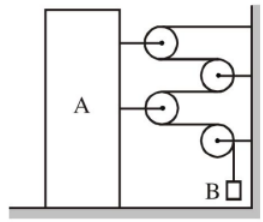
(A) 2.4 m/s² (B) 9.4 m/s²
(C) 6.9 m/s² (D) 4.9 m/s²

Q11. A heavy cart is pulled by a constant force F along a smooth horizontal track with the help of a rope that passes over a fixed pulley, as shown in the figure. Assume the tension in the rope remain constant and consider motion of the cart until it reaches vertically below the pulley. As the cart moves to the right, its acceleration



(A) decreases.
(B) increases.
(C) remains constant.
(D) is zero

Q12. Block A is moving away from the wall at a speed v and acceleration a.



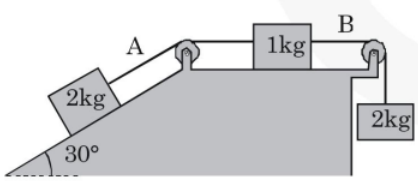
(A) Velocity of B is v with respect to A.
(B) Acceleration of B is a with respect to A.
(C) Acceleration of B is 4a with respect to A.
(D) Acceleration of B is $\sqrt{17}$a with respect to A.

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. System shown in the figure is released from rest. [g = 10 m/s^2]
Which of the following statements is (are) true?

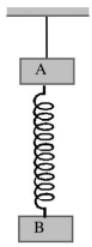


(A) Magnitude of acceleration of each block is 2 m/s^2.
(B) Tension in the cord A is more than that in cord B.
(C) Tension in the cord A is less than that in cord B.
(D) Magnitude of difference in tensions in both the cords is 2 N.

Q2. A carpenter of mass 50 kg is standing on a weighing machine placed in a lift of mass 20 kg. A light string is attached to the lift. The string passes over a smooth pulley and the other end is held by the carpenter as shown. When carpenter keeps the lift moving upward with constant velocity (g = 10 m/s^2)

(A) the reading of weighing machine is 15 kg
(B) the man applies a force of 350 N on the string
(C) net force on the man is 150 N
(D) Net force on the weighing machine is 150 N

Q3. In the given figure both the blocks have equal mass. When the thread is cut, which of the following statements give correct description immediately after the thread is cut?



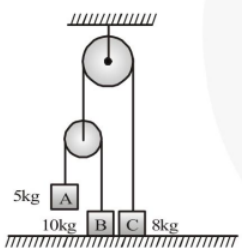
(A) Relative to the block A, acceleration of block B is 2g upwards.

(B) Relative to the block B, acceleration of block A is 2g downwards.

(C) Relative to the ground, accelerations of the blocks A and B are both g downwards.

(D) Relative to the ground, accelerations of the blocks A and B are 2g downwards and zero respectively.

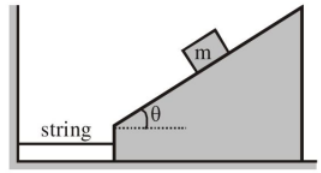
Q4. In the following arrangement the system is initially at rest. The 5 kg block is now released. Assuming the pulleys and string to be massless and smooth, the acceleration of blocks is [g = 10 m/s^2]



(A) $a_A = \frac{g}{7}$ (B) $a_B = 0$ m/s^2

(C) $a_C = \frac{5}{7}$ m/s^2 (D) $2a_C = a_A$

Q5. Refer the system shown in the figure. Block is sliding down the wedge. All surfaces are frictionless. Find correct statement(s) :



(A) Acceleration of block is gsinθ

(B) Acceleration block is gcosθ

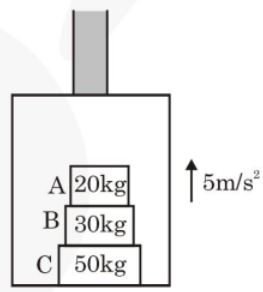
(C) Tension in the string is mgcos^{2}θ

(D) Tension in the string is mgsinθ.cosθ

MATCHING LIST TYPE

Each question has TWO (02) ***matching lists: LIST I and LIST II****. FOUR options are given representing matching of elements from LIST I and LIST II.ONLY ONE of these four options corresponds to a correct matching For each question, choose the option corresponding to the correct matching.*

Q6. In shown situation elevator is moving upward with acceleration of 5 m/s^2.



List-I	List-II
(P) Net force acting on B	(1) 150 N
(Q) Normal reaction between A and B	(2) 300 N
(R) Normal reaction between B and C	(3) 750 N
(S) Normal reaction between C and elevator	(4) 1500 N

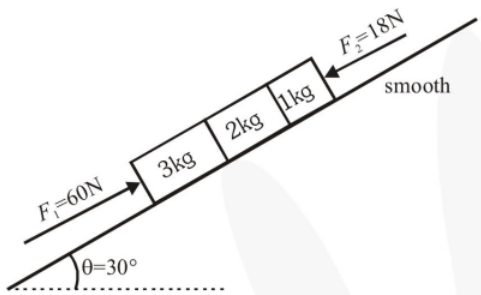
Code :

	P	Q	R	S
(A)	1	2	3	4
(B)	2	4	3	1
(C)	1	2	4	3
(D)	3	2	1	4

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q7. In the diagram shown in figure ($g = 10\ m/s^2$)



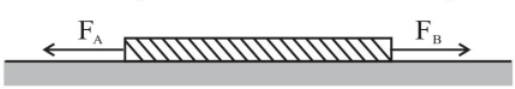
Column I	Column II
(A) Acceleration of 2 kg block in m/s^2	(P) 8
(B) Net force on 3 kg block in newton	(Q) 25
(C) Normal reaction between 2 kg and 1 kg in newton	(R) 2
(D) Normal reaction between 3 kg and 2 kg in newton	(S) 45
	(T) None

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph # 1 (Ques. 8 to 11)

A uniform rope of mass (m) and length (L) placed on frictionless horizontal ground is being pulled by two forces F_A and F_B at its ends as shown in the figure. As a result, the rope accelerates toward the right.



Q8. Acceleration (A) of the rope is -

(A) zero

(B) $a = \frac{F_A + F_B}{m}$

(C) $a = \frac{F_A - F_B}{m}$

(D) $a = \frac{F_B - F_A}{m}$

Q9. Tension (T) at the mid point of the rope is -

(A) $T = F_B - F_A$

(B) $T = F_A + F_B$

(C) $T = \frac{1}{2}(F_B - F_A)$

(D) $T = \frac{1}{2}(F_A + F_B)$

Q10. Expression (T_x) of tension at a point at distance x from the end A is -

(A) $T_x = \left(\frac{F_B - F_A}{L}\right)x + F_A$

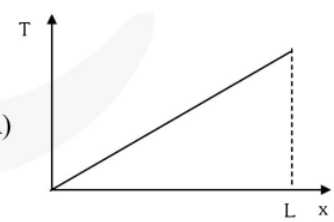
(B) $T_x = \left(\frac{F_B - F_A}{L}\right)x - F_A$

(C) $T_x = \left(\frac{F_B - F_A}{L}\right)x + F_B$

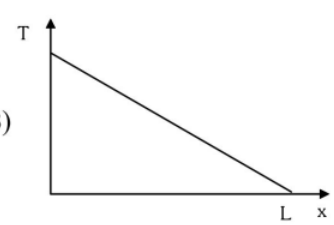
(D) $T_x = \left(\frac{F_B - F_A}{L}\right)x - F_B$

Q11. Which of the following graph best represents variation in tension at a point on the rope with distance x of the point from the end A?

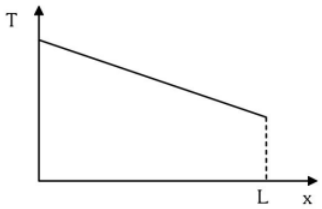
(A)



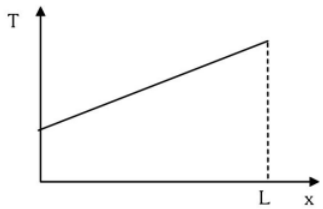
(B)



(B)

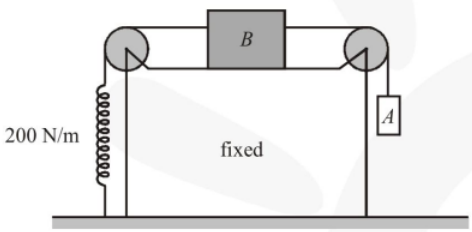


(D)



Paragraph # 2 (Ques. 12 to 14)

The figure shown blocks A and B are of mass 2 kg and 8 kg and they are connected through strings to a spring connected to ground. The blocks are in equilibrium. ($g = 10 m/s^2$)



Q12. The elongation of the spring is -

(A) 1 cm (B) 10 cm

(C) 0.1 cm (D) 1m

Q13. Now the block A is pulled downwards by a force gradually increasing to 20 N. The new elongation of spring is -

(A) 2 cm (B) 4 cm

(C) 20 cm (D) 40 cm

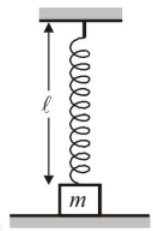
Q14. Now the force on A is suddenly removed. The acceleration of block B becomes -

(A) 1.0 m/s (B) 2.0 m/s^2

(C) 3.0 m/s^2 (D) 4.0 m/s^2

Paragraph # 3 (Ques. 15 to 17)

A block of mass m is placed on a smooth horizontal floor is attached to one end of spring. The other end of the spring is attached to fixed support. When spring is vertical it is relaxed. Now the block is pulled towards right by a force F, which is being increased gradually. When the spring makes angle 53° with the vertical, block leaves the floor.



Q15. When blocks leaves the table, the normal force on it from table is -

(A) mg (B) zero

(C) $\frac{4mg}{3}$ (D) $\frac{3mg}{4}$

Q16. Force constant of the spring is -

(A) $\frac{5mg}{2\ell}$ (B) $\frac{15mg}{8\ell}$

(C) $\frac{5mg}{3\ell}$ (D) $\frac{5mg}{4\ell}$

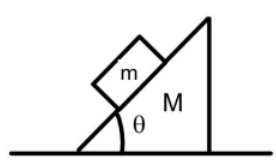
Q17. When the block leaves the table, the force F is -

(A) $\frac{3mg}{4}$ (B) $\frac{4mg}{3}$

(C) $\frac{3mg}{5}$ (D) $\frac{4mg}{5}$

SUBJECTIVE TYPE

Q18. A block of mass m lies on wedge of mass M as shown in figure.



With what minimum acceleration must the wedge be moved towards right horizontally so that block m falls freely.

Answer Key

Ex-1											
1	2	3	4	5	6	7	8	9	10	11	12
B	A	C	B	C	D	B	B	D	D	C	C
13	14	15	16	17	18	19	20	21	22	23	24
B	A	B	B	C	C	B	A	D	C	A	D
25	26	27									
A	C	C									

Ex- 1A

1. B, C **2.** C, D **3.** A, C **4.** A, B

5. (i) $\frac{M_1}{M_2} = \frac{1}{3}$ (ii) a=3/4 m/s^2 **6.** 2 **7.** 200N, 10m/s^2

8. $v_0 / \cos\theta$ **9.** (A)-Q, (B)-R, (C)-S, (D)-P **10.** (A)-T, (B)-R, (C)-R, (D)-Q

11. (A)-R, (B)-T, (C)-R, (D)-P **12.** B

Ex-2											
1	2	3	4	5	6	7	8	9	10	11	12
B	A	D	C	C	B	D	A	C	D	A	D

Ex- 2A

1. A,C,D **2.** A,B **3.** A,B,D **4.** A,B,C,D **5.** A,D

6. A **7.** (A)-R, (B)-T, (C)-Q, (D)-T **8.** D **9.** D

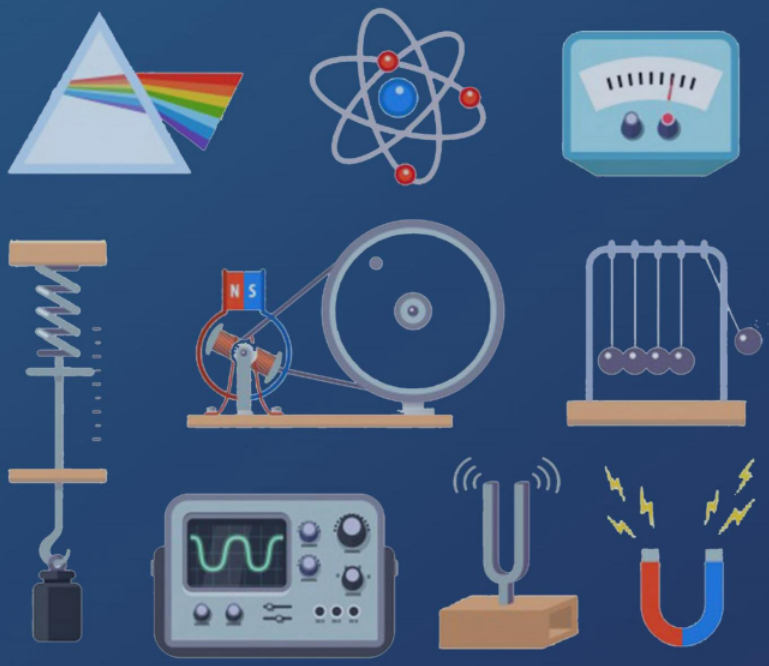
10. A **11.** D **12.** B **13.** C **14.** B

15. B **16.** A **17.** B **18.** a = g cotθ

-: Important Notes & Formulas :-

PHYSICS

Nuclear Physics



SHEET

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3.	Exercise 1	Page - 1
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5.	Exercise 2	Page - 5
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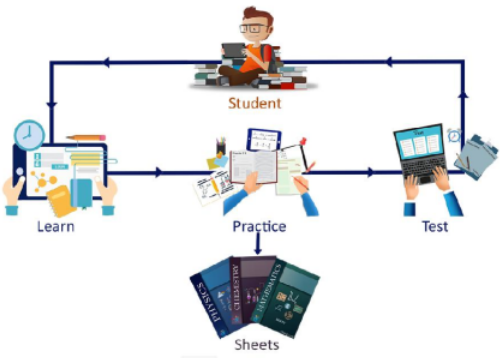
7.	Answer Key	Page - 9

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Introduction to Nuclear Physics	1,2			1,2
2	Nuclear force theory	3-5	1,11-14,16	1,2	
3	Binding energy and mass defect	6-18	2-6,15	3,4	8,10
4	Q value of a nuclear reaction	19-22	7-9	5-7	9,11,12
5	Where does the Q value go?				3
6	Which nucleus is more stable?	23	10		
7	Life lesson from Einstein				
8	Einstein and his world's most famous equation				
9	After Full Chapter	24		8,9	4-7

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Introduction to Nuclear Physics

Q1. The mass number of a nucleus is -
(A) Always less than atomic number
(B) Always more than atomic number
(C) Equal to atomic number
(D) Sometimes more or equal to atomic number.

Q2. As the mass number A increases, which of the following quantities related to a nucleus do not change :
(A) mass
(B) volume
(C) density
(D) binding energy

Nuclear Force Theory

Q3. The surface area of a nucleus varies with mass number A as :
(A) $A^{2/3}$ (B) $A^{1/3}$
(C) A (D) None

Q4. The radius of the nuclues is proportional to, (if A is the atomic mass number).
(A) A (B) A^3
(C) $A^{1/3}$ (D) $A^{2/3}$

Q5. The nucleus of $_{56}Ba^{141}$ contains.
(A) 85 protons, 56 neutrons
(B) 55 protons ,86 neutrons
(C) 56 protons,85 neutrons
(D) 86 protons,55neutrons

Binding energy and mass defect

Q6. Masses of nucleus, neutron and protons are M, M_n and M_p respectivly, then :-
(A) $M = (A-Z)\,M_n + ZM_p$
(B) $M = ZM_n + (A-Z)\,M_p$
(C) $M > (A-Z)\,M_n + ZM_p$
(D) $M < (A-Z)\,M_n + ZM_p$

Q7. The value of binding energy for $_1H^2$, $_2He^4$, $_{26}Fe^{56}$, $_{92}U^{235}$ are 2.22, 28.3, 492 and 1786 units respectively. Then most stable nucleus is-
(A) $_{26}Fe^{56}$ (B) $_1H^2$
(C) $_{92}U^{235}$ (D) $_2He^4$

Q8. How much energy will be released when 10 kg of U^{235} gets completely converted into energy :-
(A) 5×10^{27} MeV
(B) 5×10^{24} MeV
(C) 9×10^{17} J
(D) All of these

Q9. If M_0 is the mass of an oxygen isotope $_8O^{17}$, M_p and M_n are the masses of a proton and a neutron, respectively, the nuclear binding energy of the isotope is -
(1) $(M_o - 8M_p)c^2$
(2) $(M_o - 8Mp - 9M_n)c^2$
(3) M_oc^2
(4) $(M_o - 17M_n)c^2$

Q10. The difference between mass of the nucleus and total mass of its constituents is called :
(A) Packing fraction
(B) Mass defect
(C) Binding energy
(D) Binding energy per neucleon

Q11. The parameter used to measure the stability of the nucleus is -

(A) Average binding energy

(B) No of protons

(C) No of neutrons

(D) No of electrons

Q12. When the number of nucleons in a nuclues increases the binding energy per nucleon.

(A) Increase continuously with mass number

(B) Decreases continuously with mass number

(C) Remains constant with mass number

(D) First increases and then decreases with increase in mass number

Q13. In a nuclear reaction some mass converts into energy. In this reaction total B.E of reactants when compared with that of products is -

(A) always greater

(B) always less

(C) either greater or less

(D) always equal

Q14. The particle A is converted to C via following reactions then -

$A \rightarrow B + {}_{2}He^{4}$

$B \rightarrow C + 2\,{}_{-1}e^{0}$

(A) A and C are isobars

(B) A and C are isotopes

(C) A and B are isobars

(D) A and B are isotopes

Q15. Energy released as mass of 2 amu is converted into energy is -

(A) 1.5×10^{-10} J

(B) 3×10^{-10} J

(C) 1863 J

(D) 931.5 Mev

Q16. The mass defect in a nucleus is 3.5 amu. Then the binding energy of the nucleus is -

(A) 32.58MeV

(B) 325.85 MeV

(C) 3260.25MeV

(D) 3.258 MeV

Q17. Let u denote one atomic mass unit. One atom of an element of mass number A has mass exactly equal to Au.

(A) for any value of A

(B) only for A = 1

(C) only for A = 12

(D) for any value of A provided the atom is stable

Q18. The binding energy per nucleon for C^{12} is 7.68 MeV and that for C^{13} is 7.5 MeV. The energy required to remove a neutron from C^{13} is -

(A) 5.34 MeV (B) 5.5 MeV

(C) 9.5 MeV (D) 9.34 MeV

Q value of a nuclear reaction

Q19. Binding energy per nucleon of deutron is 1.112 MeV and binding energy per nucleon of an α-particle is 7.07 MeV, then in following process energy Q is :–

$$2({}_{1}H^{2}) \rightarrow {}_{2}He^{4} + Q$$

(A) 1 MeV (B) 11.9 MeV

(C) 23.8 MeV (D) 931 MeV

Q20. The nucleus of element X (A = 220) undergoes α-decay. If Q-value of the reaction is 5.5 MeV, then the kinetic energy of α-particle is :

(A) 5.4 MeV (B) 10.8 MeV

(C) 2.7 MeV (D) None

Q21. Consider the nuclear reaction :

$X^{200} \rightarrow A^{110} + B^{90} + \text{energy}$

The binding energy per nucleon for X^{200}, A^{110} and B^{90} is respectively 7.4MeV, 8.2MeV and 8.2Mev. The energy released is -

(A) 200MeV (B) 160MeV

(C) 110MeV (D) 90MeV

Q22. Binding energy per nucleon for deuteron and α Particle are x_1 and x_2 in the following equation :

${}_1H^2 + {}_1H^2 \rightarrow {}_2He^4 + Q$

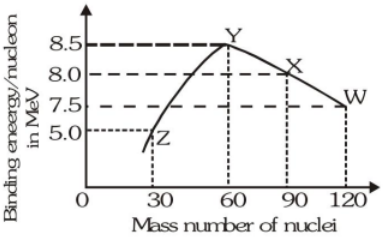
The value of energy (Q) released is :-

(A) $4(x_2 - x_1)$ (B) $4(x_1 + x_2)$

(C) $(x_1 - x_2)$ (D) $(x_1 + x_2)$

Which nucleus is more stable?

Q23. Binding energy per nucleon versus mass number curve for nuclei is shown in figure. W, X, Y and Z are four nuclei indicated on the curve. The process that would release energy is :



(A) $Y \rightarrow 2Z$

(B) $W \rightarrow X + Z$

(C) $W \rightarrow 2Y$

(D) $X \rightarrow Y + Z$

After Full Chapter

Q24. A γ ray photon produces an electron positron pair, If the rest mass energy of electron is 0.51 Mev and the total kinetic energy of electron - positron pair is 0.78 MeV then the energy of γ - ray photon in Mev is :-

(A) 0.78 (B) 1.8

(C) 1.28 (D) 0.28

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. If a nucleus is emitting e^- particle, its neutron to proton ratio $\left[\frac{n}{p}\right]$ will :–

(A) increase

(B) decrease

(C) remain unchanged

(D) can't be determined

Q2. If radius of the ${}^{27}_{13}Al$ nucleus is estimated to be 3.6 fermi, then the radius of ${}^{125}_{52}Te$ nucleus be nearly-

(A) 6 fermi (B) 8 fermi

(C) 4 fermi (D) 5 fermi

Q3. The binding energies of nuclei X and Y are E_1 and E_2 respectively. Two atoms of X fuse to give one atom of Y and an energy Q is released. Then:

(A) $Q = 2E_1 - E_2$

(B) $Q = E_2 - 2E_1$

(C) $Q = 2E_1 + E_2$

(D) $Q = 2E_2 + E_1$

Q4. The correct statements about binding energy is -

(A) It is the sum of the rest mass energies of nucleons minus the rest mass energy of the nucleus.

(B) It is the energy released when the nucleons combine to form a nucleus.

(C) It is the energy required to break a given nucleus into its constituent nucleons.

(D) It is the sum of the kinetic energies of all the nucleons in the nucleus.

Q5. The binding energies of a deuteron and an α-particle are 1.125, 7.2 MeV/nucleon respectively. The more stable of the two, is-

(A) deuteron

(B) α-particle

(C) both

(D) sometimes deutron and sometimes α-particle

Q6. Mass defect of an atom refers to -

(A) Inaccurate measurement of mass of neutrons

(B) Mass annihilated to produce energy to bind the nucleons

(C) Packing fraction

(D) Difference in the number of neutrons and protons in the nucleus

Q7. The binding energies of the atom of elements A & B are E_a & E_b respectively. Three atoms of the element B fuse to give one atom of element A. This fusion process is accompanied by release of energy e. Then E_a, E_b are related to each other as :

(A) $E_a + e = 3E_b$

(B) $E_a = 3E_b$

(C) $E_a - e = 3E_b$

(D) $E_a + 3E_b + e = 0$

Q8. The binding energy per nucleon of deuteron (^2_1H) and helium nucleus (^4_2He) is 1.1 MeV and 7 MeV respectively. If two deuteron nuclei react to form a single helium nucleus, then the energy released is -

(A) 13.9 MeV (B) 26.9 MeV

(C) 23.6 MeV (D) 19.2 MeV

Q9. Which of these are conserved in a nucleus reaction :

(A) Mass number (B) Charge number

(C) Energy (D) None of these

Q10. The instability of the nucleus can be due to various causes. An unstable nucleus emits radiations if possible to transform into less unstable state. Then the cause and the result can be :

(A) a nucleus of excess nucleons is α active

(B) an excited nucleus of excess protons is β^- active

(C) an excited nucleus of excess protons is β^+ active

(D) an nucleus of excess neutrons is β^- active

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question. 11 to 13

Atomic nucleus is central core of every atom in which the whole of positive charge and almost entire mass of atom is concentrated. It is a tiny sphere of radius R is given by $R = R_o A^{1/3}$, where $R_o = 1.4 \times 10^{-15}$ m, a constant and A is the mass number of the nucleus.

Q11. A graph between '$\log\left(\frac{R}{R_o}\right)$, and 'log A'

(A) Is a parabola

(B) Is a straight line passing through origin

(C) Is a straight line have an intercept

(D) Is an ellipse

Q12. On increasing the value of 'A' the density of the nucleus.

(A) Increases

(B) Decreases

(C) Remains constant

(D) None

Q13. The radius of the nucleus of mass number 125 is -

(A) 175×10^{-15} m (B) 35×10^{-15} m

(C) 70×10^{-15} m (D) 7×10^{-15} m

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q14. Carbon has two stable isotopes. Natural carbon has 98.9% carbon–12 and 1.1% carbon–13, calculate the average atomic weight of carbon in amu.

Q15. Calculate the binding energy of $_{17}Cl^{35}$ (in MeV)if mass of $_{17}Cl^{35}$ nucleus is 34.98 amu, mass of neutron is 1.008665 amu, and mass of proton is 1.007277 amu.

SUBJECTIVE TYPE

Q16. Two nuclei have their mass numbers in ratio 1 : 3. What is the ratio of nuclear densities?

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Let F_{pp}, F_{pn} and F_{nn} denote the nuclear force between proton–proton, proton–neutron and neutron–neutron pair respectively. When separation is 1 fm :-

(A) $F_{pp} < F_{pn} = F_{nn}$ (B) $F_{pp} > F_{pn} = F_{nn}$

(C) $F_{pp} = F_{pn} = F_{nn}$ (D) $F_{pp} < F_{pn} < F_{nn}$

Q2. A nucleus disintegrates into two nuclear parts which have their velocities in the ratio 2 : 1. The ratio of their nuclear sizes will be :-

(A) $2^{1/3} : 1$ (B) $1 : 3^{1/2}$

(C) $3^{1/2} : 1$ (D) $1 : 2^{1/3}$

Q3. If a star can convert all the He nuclei completely into oxygen nuclei. The energy released per oxygen nuclei is : [Mass of the helium nucleus is 4.0026 amu and mass of oxygen nucleus is 15.9994 amu]

(A) 7.6 MeV

(B) 56.12 MeV

(C) 10.24 MeV

(D) 23.4 MeV

Q4. The mass of proton is 1.0073 u and that of neutron is 1.0087 u (u = atomic mass unit).

The binding energy of $_2^4He$ is :-

[Given helium nucleus mass $\approx$4.0015u]

(A) 0.0305 J

(B) 0.0305 erg

(C) 28.4 MeV

(D) 0.061 u

Q5. The binding energy of deuteron is 2.2 MeV and that of $_2^4$He is 28 MeV. If two deuterons are fused to form one ^4_2He then the energy released is :-

(A) 23.6 MeV (B) 19.2 MeV

(C) 30.2 MeV (D) 25.8 MeV

Q6. Per nucleon energy of $_3Li^7$ and $_2He^4$ nucleus is 5.60 MeV and 7.06 MeV, then in $_3Li^7 + {}_1P^1 \rightarrow 2{}_2He^4$ energy released is :-

(A) 29.6 MeV (B) 2.4 MeV

(C) 8.4 MeV (D) 17.3 MeV

Q7. In an α-decay the Kinetic energy of α particle is 48 MeV and Q-value of the reaction is 50 MeV. The mass number of the mother nucleus is : (Assume that daughter nucleus is in ground state)

(A) 96 (B) 100

(C) 104 (D) none of these

Q8. When U^{238} nucleus originally at rest, decays by emitting an alpha particle having a speed u, the recoil speed of the residual nucleus is-

(A) $\frac{4u}{238}$ (B) $-\frac{4u}{234}$

(C) $\frac{4u}{234}$ (D) $-\frac{4u}{238}$

Q9. An alpha nucleus of energy $\frac{1}{2}mv^2$ bombards a heavy nuclear target of charge Ze. Then the distance of closest approach for the alpha nucleus will be proportional to -

(1) v^2 (2) 1/m

(3) $1/v^4$ (4) 1/Ze

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Consider the following nuclear reactions and select the correct statements from the options that follow :

Reaction I : $n \rightarrow p + e^- + \bar{\nu}$

Reaction II : $p \rightarrow n + e^+ + \nu$

(A) Free neutron is unstable, therefore reaction I is possible

(B) Free proton is stable, therefore reaction II is not possible

(C) Inside a nucleus, both decays (reaction I and II) are possible

(D) Inside a nucleus, reaction I is not possible but reaction II is possible.

Q2. A nuclear transformation is denoted by $X(n, \alpha) \rightarrow {}^7_3Li$. Which of the following is the nucleus of element X ?

(A) $^{12}_6C$ (B) $^{10}_5B$

(C) ^9_5B (D) $^{11}_4Be$

Q3. In the options given below, let E denote the rest mass energy of a nucleus and *n* a neutron. The correct option is :-

(A) $E\left(^{236}_{92}U\right) > E\left(^{137}_{53}I\right) + E\left(^{97}_{39}Y\right) + 2E(n)$

(B) $E\left(^{236}_{92}U\right) < E\left(^{137}_{53}I\right) + E\left(^{97}_{39}Y\right) + 2E(n)$

(C) $E\left(^{236}_{92}U\right) < E\left(^{140}_{56}Ba\right) + E\left(^{94}_{36}Kr\right) + 2E(n)$

(D) $E\left(^{236}_{92}U\right) = E\left(^{140}_{56}Ba\right) + E\left(^{94}_{36}Kr\right) + 2E(n)$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 4 to 7

When subatomic particles undergo reactions, energy is conserved, but mass is not necessarily conserved. However, a particle's mass 'contributes' to its total energy, in accordance with Einstein's famous equation, $E = mc^2$

In this equation, E denotes the equivalent energy when a particle of mass m is converted into energy. The particle can also have additional energy due to its motion and its interactions with other particles.

Consider a neutron at rest, and well separated from other particles. It decays into a proton, an electron, and an undetected third particle:

Neutron $\rightarrow$ proton + electron + third particle

The table below summarizes some data from a single nuetron decay. Column 2 shows the rest mass of the particle times the speed of light squared.

Particle	**Mass x c^2 (MeV)**	**Kinetic Energy (MeV)**
Neutron	940.97	0
Proton	939.66	0.02
Electron	0.51	0.42

Q4. Assuming the table contains no major errors, what can we conclude about the (mass x c^2) of the undetected third particle?

(A) It is 0.90 MeV

(B) It is 0.36 MeV

(C) It is less than or equal to 0.90 MeV; but we cannot be more precise

(D) It is less than or equal to 0.36 MeV; but we cannot be more precise

Q5. From the given table, which properties of the undetected third particle can we calculate?

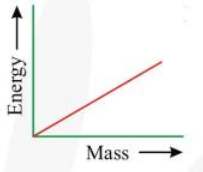
(A) Total energy, but not kinetic energy

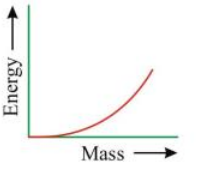
(B) Kinetic energy, but not total energy

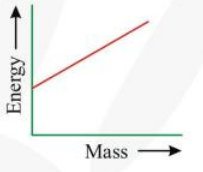
(C) Both total energy and kinetic energy

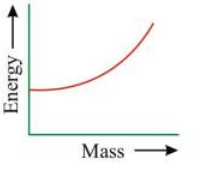
(D) Neither total energy nor kinetic energy

Q6. Consider an ensemble of particles, all of which have the same positive kinetic energy but different masses. For this ensemble, which graph best represents the relationship between the particle's mass and its total energy?

(A) 

(B) 

(C) 

(D) 

Q7. Could this reaction occur?

Proton $\rightarrow$ neutron + other particles

(A) Yes, if the other particles have much more kinetic energy than mass energy

(B) Yes, but only if the proton has potential energy (due to interactons with other particles)

(C) No, because a neutron is more massive than a proton

(D) No, because a proton is positively charged while a neutron is electrically neutral.

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q8. In the following, column I lists some physical quantities & the column II gives approx. energy values associated with some of them. Choose the appropriate value of energy from column II for each of the physical quantities in column I and write the corresponding letter A, B, C etc. against the number (i), (ii), (iii), etc. of the physical quantity in the answer book. In your answer, the sequence of column I should be maintained.

Column I	**Column II**
(i) Energy of thermal neutrons	(A) 0.025 eV
(ii) Energy of X-rays	(B) 0.5 eV
(iii) Binding energy per nucleon	(C) 3 eV
(iv) Photoelectric threshold of metal	(D) 20 eV
	(E) 10 keV
	(F) 8 MeV

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q9. The binding energies per nucleon for deuteron ($_1H^2$) and helium ($_2He^4$) are 1.1 MeV and 7.0 MeV respectively. Find the energy released (in MeV) when two deuterons fuse to form a helium nucleus ($_2He^4$).

SUBJECTIVE TYPE

Q10. The Q value of a nuclear reaction

$A + b \rightarrow C + d$ is defined by

$Q = [m_A + m_b - m_C - m_d]c^2$

where the masses refer to the respective nuclei. Determine from the given data the Q-value of the following reactions and state whether the reactions are exothermic or endothermic.

(i) $_1^1H + _1^3H \rightarrow _1^2H + _1^2H$

(ii) $_6^{12}C + _6^{12}C \rightarrow _{10}^{20}Ne + _2^4He$

Atomic masses are given to be :

$m(_1^2H) = 2.014102$ u

$m(_1^3H) = 3.016049$ u

$m(_6^{12}C) = 12.000000$ u

$m(_{10}^{20}Ne) = 19.992439$ u

Q11. Suppose that the Sun consists entirely of hydrogen atom and releases the energy by the nuclear reaction, $4\,_1^1H \longrightarrow {}_2^4He$ with 26 MeV of energy released. If the total output power of the Sun is assumed to remain constant at 3.9×10^{26} W, find the time it will take to burn all the hydrogen. Take the mass of the Sun as 1.6×10^{30} kg.

Q12. The kinetic energy of an α – particle which flies out of the nucleus of a Ra^{226} atom in radioactive disintegration is 4.78 MeV. Find the total energy evolved during the escape of the α – particle.

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	C	A	C	C	D	A	C	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	D	B	B	B	C	C	A	C	A
21	**22**	**23**	**24**						
B	A	C	B						

Ex-1A

1. B **2.** A **3.** B **4.** A,B,C **5.** B

6. B **7.** C **8.** C **9.** A,B,C **10.** A,C,D

11. B **12.** C **13.** D **14.** 12.011 u **15.** 278.92 MeV

16. 1:1

Ex-2								
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
C	D	C	C	A	D	B	C	B

Ex-2A

1. A,B,C **2.** B **3.** A **4.** D **5.** A

6. C **7.** B **8.** (i) A, (ii) E (iii) F (iv) C **9.** 23.6

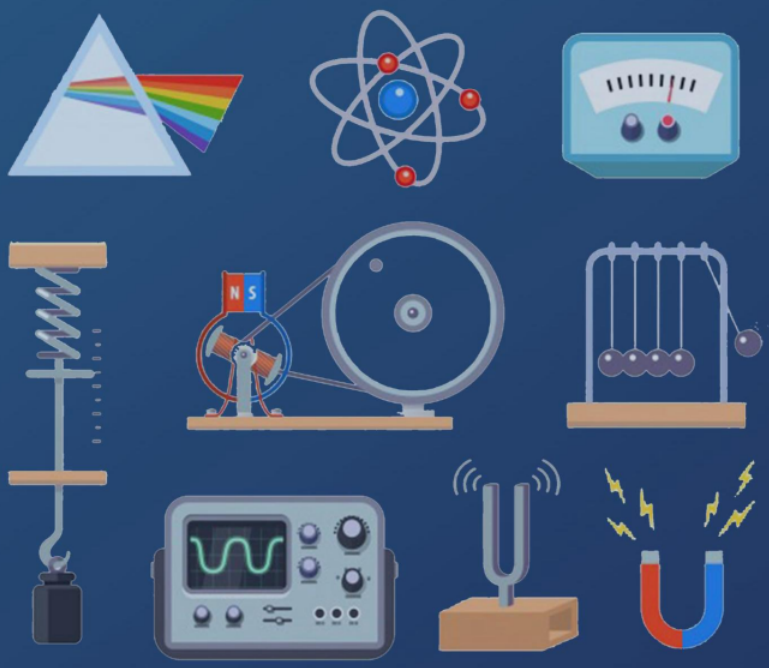
10. (i) –4.054 MeV, endothermic (ii) 5.64 MeV, exothermic

11. $8/3\times10^{18}$ sec **12.** 4.87 MeV

-: Important Notes & Formulas :-

PHYSICS

Radioactivity



SHEET

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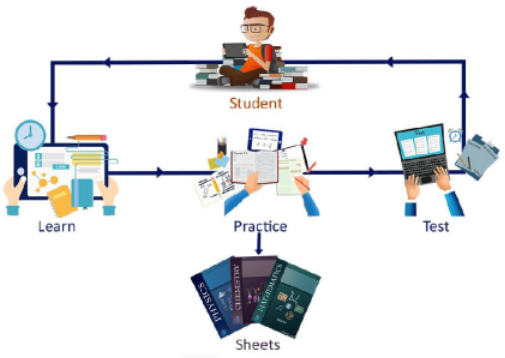
5.	Exercise 2	Page - 6
6.	Exercise 2A	Page - 8
7.	Answer Key	Page - 12

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Various types of radioactivity Decay	1-7	1-5	1,2	1,19
2	Radioactive Derivation	8-12	6-7,14-16	3-13	2-7,20
3	Activity of a radioactivity sample	13-16	10-12,20	14-16	8,21
4	Application of radioactivity		17	17,18	9,18,22
5	Nuclear fission reaction and nuclear reactor	17-22	8,18,19	19-21	10,23,24
6	Nuclear fusion	23-25		22	
7	After Full Chapter		9,13		11-17

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Various types of radioactive Decay

Q1. Which of the following is true for isotopes of specimen of U^{235} and U^{238} -

(A) both contain same number of neutrons

(B) both contain same of number of proton, electron and neutron

(C) both contain same number of proton and electron but U^{238} contains three more neutrons than U^{235}

(D) U^{238} contain three less neutrons than U^{235}

Q2. Which one of the following pairs of nuclei are isotones :-

(A) $_{34}Se^{74}$, $_{31}Ga^{71}$

(B) $_{42}Mo^{92}$, $_{40}Zr^{92}$

(C) $_{38}Sr^{84}$, $_{38}Sr^{86}$

(D) $_{20}Ca^{40}$, $_{16}S^{32}$

Q3. A nucleus with Z = 92 emits the following in a sequence : $\alpha, \alpha, \beta^-, \beta^-, \alpha, \alpha, \alpha, \alpha, \beta^-, \beta^-, \alpha, \beta^+, \beta^+, \alpha$. The Z of the resulting nucleus is-

(A) 76 (B) 78

(C) 82 (D) 74

Q4. In the uranium radioactive series the initial nucleus is $_{92}U^{238}$ and the final nucleus is $_{82}Pb^{206}$. When the uranium nucleus decays to lead, the number of α,β – particles emitted is-

(A) 6, 8 (B) 8, 6

(C) 16, 6 (D) 32, 12

Q5. When $_3Li^7$ nuclei are bombarded by protons and the resultant nuclei are $_4Be^8$, the emitted particles will be-

(A) alpha particles

(B) beta particles

(C) gamma photons

(D) neutrons

Q6. Which of the following cannot be emitted by radioactive substances during their decay?

(A) Protons (B) Neutrinos

(C) Helium nuclei (D) Electrons

Q7. In gamma ray emission from a nucleus -

(1) both the neutron number and the proton number change

(2) there is no change in the proton number and the neutron number

(3) only the neutron number changes

(4) only the proton number changes

Radioactive Derivation

Q8. The half life of a neutron is 800 sec. 10^8 neutrons at a certain instant are projected from one space station towards another space station, situated 3200 km away with a velocity 2000 m/s. Their velocity remains constant during the journey. How many neutrons reach the other station?

(A) 50×10^6 (B) 25×10^6

(C) 80×10^5 (D) 25×10^5

Q9. A radioactive nuclide can decay simultaneously by two different processes which have decay constants λ_1 and λ_2. The effective decay constant of the nuclide is λ, then :

(A) $\lambda = \lambda_1 + \lambda_2$ (B) $\lambda = 1/2(\lambda_1 + \lambda_1)$

(C) $\frac{1}{\lambda} = \frac{1}{\lambda_1} + \frac{1}{\lambda_2}$ (D) $\lambda = \sqrt{\lambda_1 \lambda_2}$

Q10. The half life of a radioactive element is 30days, in 90days the percentage of disintegrated part is-

(A) 13.5 %
(B) 46.5 %
(C) 87.5%
(D) 90.15%

Q11. 'Rn' decays into 'Po' by emitting α - particle with half life of 4 days, A sample contains 6.4×10^{10} atoms of Rn. After 12 days, the number of atoms of 'Rn' left in the sample will be-

(A) 3.2×10^{10}
(B) 0.53×10^{10}
(C) 2.1×10^{10}
(D) 0.8×10^{10}

Q12. In a radioactive element the fraction of initial amount remaining after its mean life time is-

(A) $1 - \frac{1}{e}$
(B) $\frac{1}{e^2}$
(C) $\frac{1}{e}$
(D) $1 - \frac{1}{e^2}$

Activity of a radioactivity sample

Q13. A radioactive substance is dissolved in a liquid and the solution is heated. The activity of the solution.

(A) is smaller than that of element
(B) is greater than that of element
(C) is equal to that of element
(D) will be smaller or greater depending upon whether the solution is weak or concentrated.

Q14. Activity of a radioactive substance is R_1 at time t_1 and R_2 at time $t_2 (t_2 > t_1)$. Then the ratio $\frac{R_2}{R_1}$ is :

(A) $\frac{t_2}{t_1}$
(B) $e^{-\lambda(t_1+t_2)}$
(C) $e\left(\frac{t_1 - t_2}{\lambda}\right)$
(D) $e^{\lambda(t_1-t_2)}$

Q15. Atomic weight of a radioactive element is M_w gm. Radioactivity of m gm. of its mass is :-

(N_A = Avogadro number, λ = decay constant)

(A) $N_A \lambda$
(B) $\left[\frac{N_A}{M_w} m\right]\lambda$
(C) $\left[\frac{N_A}{m}\right]\lambda$
(D) $\left[\frac{N_A}{m} M_w\right]\lambda$

Q16. What is curie -

(A) measurement of radioacitivty
(B) measurement of temperature
(C) measurement of magnetism
(D) measurement of electric field

Nuclear fission reaction and nuclear reactor

Q17. A nuclear fission is given below

$A^{240} \rightarrow B^{100} + C^{140} + Q(\text{energy})$

Let binding energy per nucleon of nucleus A, B and C is 7.6 MeV, 8.1 MeV and 8.1 MeV respectively. Value of Q is :- (Approximately)

(A) 20 MeV
(B) 220 MeV
(C) 120 MeV
(D) 240 MeV

Q18. In any fission process the ratio $\frac{\text{mass of fission products}}{\text{mass of parent nucleus}}$ is :-

(A) less than 1
(B) greater than 1
(C) equal to 1
(D) depends on the mass of the parent nucleus

Q19. Heavy water is -

(A) Water at 4^0C
(B) Watercontaining various salts
(C) Compound of heavy oxygen and hydrogen
(D) Compound of oxygen and deuterium.

Q20. Nuclear reactor is surrounded by concrete walls to -

(A) Strengthen the construction

(B) Control the chain reaction

(C) form a protective shield

(D) as moderator

Q21. Substance used to slow down the fast neutrons released during nuclear fission is called.

(A) Fuel (B) Moderator

(C) Controlling rods (D) Reflecting rods

Q22. This question contains Statement-1 and Statement-2. Out of the four choices given after the statements, choose the one that best describes the two statements.

Statement-1 : Energy is released when heavy nuclei undergo fission or light nuclei undergo fusion.

Statement-2 : For heavy nuclei, binding energy per nucleon increases with increasing Z while for light nuclei it decreases with increasing Z.

(1) Statement-1 is false, Statement-2 is true.

(2) Statement-1 is true, Statement-2 is true; Statement-2 is a correct explanation for Statement-1.

(3) Statement-1 is true, Statement-2 is true; Statement-2 is not a correct explanation for Statement-1.

(4) Statement-1 is true, Statement-2 is false.

Nuclear fusion

Q23. Solar energy is mainly due to :-

(A) burning of hydrogen in the oxygen

(B) fission of uranium present in the Sun

(C) fusion of protons during synthesis of heavier elements

(D) gravitational contraction

Q24. The following nuclear reaction is :-

$4\ {}_1H^1 \rightarrow {}_2He^4 + 2\ {}_1e^0 + 2\ \nu + 26MeV$

(A) fission

(B) fusion

(C) disintigration

(D) scattering of α–particle

Q25. Inside the sun -

(A) Four nuclei of hydrogen combine to form two nuclei of helium.

(B) Four nuclei of hydrogen combine to form four nuclei of helium.

(C) Four nuclei of hydrogen combine to form one nucleus of helium.

(D) Four nuclei of hydrogen is transformed into one nucleus of helium.

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Which of the following is/are incorrect statements ?

(A) Beta rays are same as cathode rays

(B) Gamma rays are high energy neutrons

(C) Alpha particles are singly ionized helium atoms

(D) Protons and neutrons have exactly the same mass

Q2. A nucleus undergoes a series of decay according to the scheme

$$A \xrightarrow{\alpha} B \xrightarrow{\beta} C \xrightarrow{\alpha} D \xrightarrow{\gamma} E$$

Atomic number and mass numbers of E are 69 and 172.

(A) Atomic number of A is 72

(B) Mass number of B is 176

(C) Atomic number of D is 69

(D) Atomic number of C is 69

Q3. The instability of the nucleus can be due to various causes. An unstable nucleus emits radiations if possible to transform into less unstable state. Then the cause and the result can be

(A) a nucleus of excess nucleons is α active

(B) an excited nucleus of excess protons is β^- active

(C) an excited nucleus of excess protons is β^+ active

(D) an nucleus of excess neutrons is β^- active

Q4. When a nucleus with atomic number Z and mass number A undergoes a radioactive decay process:

(A) both Z and A will decrease, if the process is α decay

(B) Z will decrease but A will not change, if the process is β^+ decay

(C) Z will decrease but A will not change, if the process is β^- decay

(D) Z and A will remain unchanged, if the process is γ decay.

Q5. When the mass number A of the nucleus increases

(A) initially the neutron–proton ratio is constant = 1

(B) initially neutron–proton ratio increases and later decreases

(C) initially binding energy per nucleon increases and later decreases

(D) the binding energy per nucleon increases when the neutron–proton ratio increases.

Q6. Half life for certain radioactive element is 5 min. Four nuclei of that element are observed at a certain instant of time. After five minutes :

Assertion (A) : It can be definitely said that two nuclei will be left undecayed

Reasoning (R) : After half life i.e. 5 minutes, half of total nuclei will disintegrate. So only two nuclei will be left undecayed. Then -

(A) A is correct & R is correct explanation of A

(B) Both are correct. But R is not correct explanation of A

(C) A is incorrect & R is correct

(D) Both are incorrect

Q7. The decay constant of the end product of a radioactive series is

(A) zero

(B) infinite

(C) finite (non zero)

(D) depends on the end product

Q8. Which of the following is correct for a nuclear reaction?

(A) A typical fission represented by

$${}_{92}U^{235} + {}_{0}n^{1} \rightarrow {}_{56}Ba^{143} + {}_{36}Kr^{93} + \text{energy}$$

(B) Heavy water is used as moderator in preference to ordinary water because H may capture neutrons, while D would not.

(C) Cadmium rods increase the reactor power when they go in, decrease when they go outward.

(D) Slower neutrons are more effective in causing fission than faster neutrons in case of U^{235}.

Q9. When the nucleus of an electrically neutral atom undergoes a radioactive decay process, it will remain neutral after the decay if the process is :

(A) α decay (B) β^- decay

(C) γ decay (D) K-capture

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question. 10 to 12

Many unstable nuclei can decay spontaneously to a nucleus of lower mass but different combination of nucleons. The process of spontaneous emission of radiation is called radioactivity. Three types of radiations are emitted by radioactive substance. Radioactive decay is a statistical process. Radioactivity is indepndent of all external conditions.

The number of decays per unit time or decay rate is called activity. Activitiy exponentially decreases with time. Mean lifetime is always greater than half-life time.

Q10. Choose the correct statement about radio-activity.

(A) Radioactivity is a statistical process

(B) Radioactivity is independent of high temperature and high pressure

(C) When a nucleus undergoes $\alpha-$ or $\beta-$ decay, its atomic number changes

(D) All of these

Q11. If T_H is the half-life and T_M is the mean life. Which of the following statements is correct:

(A) $T_M > T_H$

(B) $T_M < T_H$

(C) Both are directly proportional to square of the decay constant

(D) $T_M \propto \lambda_0$

Q12. 'n' number of α particles per second are being emitted by N atoms of a radioactive element. The half-life of element will be :

(A) $\frac{n}{N}s$ (B) $\frac{N}{n}s$

(C) $\frac{0.693N}{n}s$ (D) $\frac{0.693n}{N}s$

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q13. Match the following Columns :-

Column 1	**Column 2**
(A) Nuclear fusion	(P) Converts some matter into energy
(B) Nuclear fission	(Q) Generally occurs for nuclei with low atomic number
(C) β–decay	(R) Generally occurs for nuclei with higher atomic number
(D) Exothermic nuclear reaction	(S) Essentially proceeds by weak nuclear forces

SUBJECTIVE TYPE

Q14. A radioactive nucleus undergoes a series of decays according to the following scheme:

$A \xrightarrow{\alpha} A_1 \xrightarrow{\beta^-} A_2 \xrightarrow{\alpha} A_3 \xrightarrow{\gamma} A_4$

If the mass number and atomic number of A are 180 and 72 respectively, what are these numbers for A_4?

Q15. The half lives of radioactive elements x and y are 3 minute and 27 minute respectively. If the activities of both are same, then calculate the ratio of number of atoms of x and y.

Q16. $\frac{2}{3}$ fraction of a sample disintegrates in 7 days. How much fraction of it will decay in 21 days?

Q17. The half life of a radioactive material is T. After T/2 time, the material left is -

Q18. ${}_{92}U^{238} \xrightarrow{\alpha} X_1 \xrightarrow{+\beta^0} {}_aX^b$, find a & b.

Q19. ${}_{92}U^{238} \xrightarrow{n\alpha, n'_\beta^0} {}_{82}Pb^{206}$. Find n & n'

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q20. After 280 days, the activity of a radioactive sample is 6000 dps. The activity reduces to 3000 dps after another 140 days. The initial activity of the sample in dps is :

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. ${}_{92}U^{235}$, nucleus absorbs a neutron and disintigrate in ${}_{54}Xe^{139}$, ${}_{38}Sr^{94}$ and X so, What will be product 'X' :-

(A) 3 - neutrons (B) 2-neutrons
(C) α - particle (D) β - particle

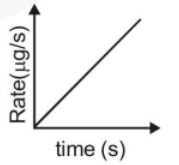
Q2. The number of α and β^- emitted during the radioactive decay chain starting from $^{226}_{88}Ra$ and ending at $^{206}_{82}Pb$ is -

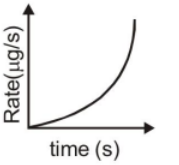
(A) 3α & $6\beta^-$ (B) 4α & $5\beta^-$
(C) 5α & $4\beta^-$ (D) 6α & $6\beta^-$

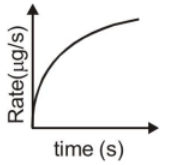
Q3. Initial ratio of active nuclei in two different samples is 2:3. Their half lives are 2hr and 3hr respectively. Ratio of their activities at the end of 12hr is:-

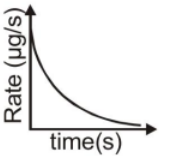
(A) 1 : 6 (B) 6 : 1
(C) 1 : 4 (D) 4 : 1

Q4. The radioactive nuclide of an element X decays to a stable nuclide of element Y. Then, in a given sample of X, the rate of formation of Y is given by the graph -

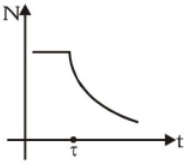
(A) 

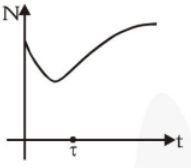
(B) 

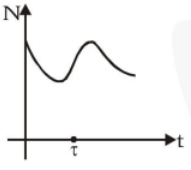
(C) 

(D) 

Q5. A radioactive sample consists of two distinct species having equal number of atoms initially. The mean life of one species is τ and that of the other is 5τ. The decay products in both cases are stable. A plot is made of the total number of radioactive nuclei as a function of time. Which of the following figure best represent the form of this plot ?

(A) 

(B) 

(C) 

(D)

Q6. The half–life of ^{131}I is 8 days. Given a sample of ^{131}I at time t = 0, we can assert that :

(A) No nucleus will decay before t = 4 days

(B) No nucleus will decay before t = 8 days

(C) All nuclei will decay before t = 16 days

(D) A given nucleus may decay at any time after t = 0

Q7. The half–life period of a radioactive element x is same as the mean life time of another radioactive element y. Initially both of them have the same number of atoms. Then :

(A) x and y have the same decay rate initially

(B) x and y decay at the same rate always

(C) y will decay at a faster rate than x

(D) x will decay at faster rate than y

Q8. Two radioactive material A_1 and A_2 have decay constants of $10\lambda_0$ and λ_0. If initially they have same number of nuclei, the ratio of number of their undecayed nuclei will be (1/e) after a time

(A) $\frac{1}{\lambda_0}$ (B) $\frac{1}{9\lambda_0}$ (C) $\frac{1}{10\lambda_0}$ (D) 1

Q9. 90% of a radioactive sample is left undecayed after time t has elapsed. What percentage of the initial sample will decay in a total time 2t :

(A) 20% (B) 19%

(C) 40% (D) 38%

Q10. Starting with a sample of pure ^{66}Cu, 7/8 of it decays into Zn in 15 min. The corresponding half-life is-

(1) 10 min (2) 15 min

(3) 5 min (4) $7\frac{1}{2}$ min

Q11. If $N_t = N_0e^{-\lambda t}$ then number of disintegrated atoms between t_1 to t_2 $(t_2 > t_1)$ will be :–

(1) $N_0\left[e^{\lambda t_2} - e^{\lambda t_1}\right]$

(2) $N_0\left[-e^{\lambda t_2} - e^{-\lambda t_1}\right]$

(3) $N_0\left[e^{-\lambda t_1} - e^{-\lambda t_2}\right]$

(4) None of these

Q12. A sample of radioactive element has a mass of 10 gm at an instant t = 0. The active mass of this element in the sample after two mean lives is :-

(A) 1.35 gm (B) 2.50 gm

(C) 3.70 gm (D) 6.30 gm

Q13. The half life of a radioactive element is 30 days, in 90 days the percentage of disintegrated part is :–

(A) 13.5 % (B) 46.5 %

(C) 87.5 % (D) 90.15 %

Q14. The activity of a radioactive sample is 9750 counts/min at t = 0 and 975 counts/min at t = 5 minute. The decay constant is appox :-

(A) 0.922 min^{-1} (B) 0.691 min^{-1}

(C) 0.461 min^{-1} (D) 0.230 min^{-1}

Q15. The activity of a sample reduces from A_0 to $A_0/\sqrt{3}$ in one hour. The activity after 3 hours more will be :

(A) $\frac{A_0}{3\sqrt{3}}$ (B) $\frac{A_0}{9}$ (C) $\frac{A_0}{9\sqrt{3}}$ (D) $\frac{A_0}{27}$

Q16. A radioactive material of half-life T was produced in a nuclear reactor at different instants, the quantity produced second time was twice of that produced first time. If now their present activities are A_1 and A_2 respectively then their age difference equals:

(A) $\frac{T}{\ln 2}\left|\ln\frac{A_1}{A_2}\right|$ (B) $T\left|\ln\frac{A_1}{A_2}\right|$

(C) $\frac{T}{\ln 2}\left|\ln\frac{A_2}{2A_1}\right|$ (D) $T\left|\ln\frac{A_2}{2A_1}\right|$

Q17. A particular nucleus in a large population of identical radioactive nuclei did survive 5 half lives of that isotope. Then the probability that this surviving nucleus will survive the next half life :

(A) $\frac{1}{32}$ (B) $\frac{1}{5}$ (C) $\frac{1}{2}$ (D) $\frac{1}{10}$

Q18. A certain radio active substance has a half life of 5 years. Thus for a nucleus in a sample of the element, the probability of decay in ten years is -

(A) 50% (B) 75%

(C) 100% (D) 60%

Q19. Energy released by 1 kg. U^{235}, when it is fissioned is? Assume 200MeV of energy is released per fission of $_{92}U^{235}$ atom.

(A) 8×10^{10} KWH (B) 5×10^{30} eV

(C) 10^{10} Joule (D) 5×10^{26} MeV

Q20. Assuming that 200 MeV of energy is released per fission of $_{92}U^{235}$ atom. Find the number of fission per second required to release1 kW power :-

(A) 3.125×10^{13} (B) 3.125×10^{14}

(C) 3.125×10^{15} (D) 3.125×10^{16}

Q21. In a certain nuclear reactor, a radioactive nucleus is being produced at a constant rate = 1000 /s. The mean life of the radionuclide is 40 minutes. At steady state, the number of radionuclide will be :

(A) 4×10^4 (B) 24×10^4

(C) 24×10^5 (D) 24×10^6

Q22. In the nuclear fusion reaction,

$$_1^2H + _1^3H \rightarrow _2^4He + n$$

given that the repulsive potential energy between the two nuclei is 7.7×10^{-14} J, the temperature at which the gases must be heated to initiate the reaction is nearly [Boltzmann's constant $k = 1.38 \times 10^{-23}$ J/K]-

(A) 10^7 K (B) 10^5 K

(C) 10^3 K (D) 10^9 K

Exercise - 2A — *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A star initially has 10^{40} deuterons. It produces energy via the processes $_1H^2 + _1H^2 \rightarrow _1H^3 + p$ and $_1H^2 + _1H^3 \rightarrow _2He^4 + n$. If the average power radiated by the star is 10^{16} W, the deuteron supply of the star is exhausted in a time of the order of :

(A) 10^6 s (B) 10^8 s (C) 10^{12} s (D) 10^{16} s

The mass of the nuclei are as follows :

$M(H^2) = 2.014$ amu ; $M(n) = 1.008$ amu ; $M(p) = 1.0087$ amu ; $M(He^4) = 4.001$ amu.

Q2. The half–life of ^{215}At is 100 μs. The time taken for the radioactivity of a sample of ^{215}At to decay to $1/16^{th}$ of its initial value is :

(A) 400μs (B) 63μs

(C) 40μs (D) 300μs

Q3. The half life of a radioactive substance is T_0. At t=0, the number of active nuclei are N_0. Select the correct alternative.

(A) The number of nuclei decayed in time internal 0–t is $N_0e^{-\lambda t}$

(B) The number of nuclei decayed in time interval 0–t is $N_0(1-e^{-\lambda t})$

(C) The probability that a radioactive nuclei does not decay in interval 0–t is $e^{-\lambda t}$

(D) The probability that a radioactive nuclei does not decay in interval $1-e^{-\lambda t}$

Q4. 7/8 fraction of a sample disintegrates in t time. How much time it will take to disintegrete 15/16 fraction :-

(A) t (B) $\frac{4}{3}t$

(C) $\frac{5}{3}t$ (D) 2t

Q5. A radioactive material decays by simultaneous emission of two particles with respective half-lives 1620 and 810 years. The time (in years) after which one–fourth of the material remains is :-

(A) 1080 (B) 2430

(C) 3240 (D) 4860

Q6. The decay constant of a radio active substance is 0.173 $(years)^{-1}$. Therefore :

(A) Nearly 63% of the radioactive substance will decay in (1/0.173) year.

(B) half life of the radio active substance is (1/0.173) year.

(C) one -forth of the radioactive substance will be left after nearly 8 years.

(D) all the above statements are true.

Q7. At time t = 0, N_1 nuclei of decay constant λ_1 & N_2 nuclei of decay constant λ_2 are mixed. The decay rate of the mixture is :

(A) $N_1N_2e^{-(\lambda_1+\lambda_2)t}$

(B) $+\left(\frac{N_1}{N_2}\right)e^{-(\lambda_1-\lambda_2)t}$

(C) $+\left(N_1\lambda_1e^{-\lambda_1t}+N_2\lambda_2e^{-\lambda_2t}\right)$

(D) $+N_1\lambda_1\,N_2\lambda_2\,e^{-(\lambda_1+\lambda_2)t}$

Q8. A radioactive sample S_1 having an activity of 5μCi has twice the number of nuclei as another sample S_2 which has an activity of 10μCi. The half lives of S_1 and S_2 can be :

(A) 20 years and 5 years, respectively

(B) 20 years and 10 years, respectively

(C) 10 years each

(D) 5 years each

Q9. The half-life of substance X is 45 years, and it decomposes to substance Y. A sample from a meteorite was taken which contained 2% of X and 14% of Y by quantity of substance. If substance Y is not normally found on a meteorite, what is the approximate age of the meteorite?

(A) 270 years (B) 135 years

(C) 90 years (D) 45 years

Q10. Which of the following statement(s) is/are correct?

(A) The rest mass of a stable nucleus is less than the sum of the rest masses of its separated nucleons.

(B) The rest mass of a stable nucleus is greater than the sum of the rest masses of its separated nucleons.

(C) In nuclear fusion, energy is released by fusion of two nuclei of medium mass (approx. 100 amu)

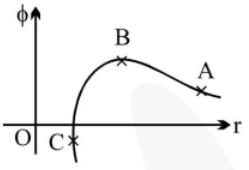
(D) In nuclear fission, energy is released by fragmentation of a very heavy nucleus.

Q11. In an α-decay the kinetic energy of α-particle is 48 MeV and Q-value of the reaction is 50MeV. The mass number of the mother nucleus is : (Assume that daughter nucleus is in ground state)

(A) 96 (B) 100

(C) 104 (D) None of these

Q12. The graph shown by the side shows the variation of potential energy ϕ of a proton with its distance 'r' from a fixed sodium nucleus, as it approaches the nucleus, placed at origin O. Then the portion.



(A) AB indicates nuclear repulsion

(B) AB indicates electrostatic repulsion

(C) BC indicates nuclear attraction

(D) BC represents electrostatic interaction

Q13. In β-decay, the Q-value of the process is E. Then

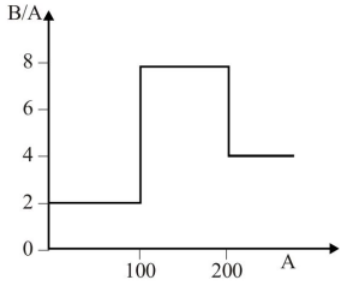
(A) K.E. of a β-particle cannot exceed E.

(B) K.E. of anti neutrino emitted lies between Zero and E.

(C) N/Z ratio of the nucleus is altered.

(D) Mass number (A) of the nucleus is altered.

Q14. Assume that the nuclear binding energy per nucleon (B/A) versus mass number (A) is as shown in the figure. Use this plot to choose the correct choice(s) given below :



(A) Fusion of two nuclei with mass numbers lying in the range of $1 < A < 50$ will release energy.

(B) Fusion of two nuclei with mass numbers lying in the range of $51 < A < 100$ will release energy.

(C) Fission of a nucleus lying in the mass range of $100 < A < 200$ will release energy when broken into two equal fragments.

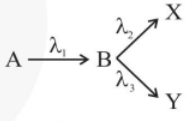
(D) Fission of a nucleus lying in the mass range of $200 < A < 260$ will release energy when broken into two equal fragments.

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question Nos. 15 to 17

The rate at which a particular decay process occurs in a radio active sample, is proportional to the number of radio active nuclei present. If N is the number of radio active nuclei present at some instant, the rate of change of N is $\frac{dN}{dt} = -\lambda N$



Consider radioactive decay of A to B which further decays either to X or Y, λ_1, λ_2 and λ_3 are decay constants for A to B decay, B to X decay and Bto Y decay respectively. At $t = 0$, the num,ber of nuclei of A,B,X and Y are N_0, N_0, zero and zero respectively. N_1, N_2, N_3 and N_4 are the number of nuclei of A,B,X and Y at any instant t.

Q15. The net rate of accumulation of B at any instant is -

(A) $N_1\lambda_1 + N_2\lambda_2 + N_3\lambda_3$

(B) $N_1\lambda_1 - N_3\lambda_2 - N_4\lambda_3$

(C) $N_1\lambda_1 - N_2\lambda_2 - N_2\lambda_3$

(D) $N_1\lambda_1 + N_2\lambda_2 - N_2\lambda_3$

Q16. The number of nuclei of B will first increase and then after a maximum value, it decreases for

(A) $\lambda_1 > \lambda_2 + \lambda_3$

(B) $\lambda_1 = \lambda_2 = \lambda_3$

(C) $\lambda_1 = \lambda_2 + \lambda_3$

(D) For any values of λ_1, λ_2 and λ_3

Q17. At $t = \infty$, which of following is incorrect?

(A) $N_2 = 0$

(B) $N_3 = \dfrac{N_0 \lambda_2}{\lambda_2 + \lambda_3}$

(C) $N_4 = \dfrac{2N_0 \lambda_3}{\lambda_2 + \lambda_3}$

(D) $N_1 + N_2 + N_3 + N_4 = 2N_0$

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q18. A wooden piece of great antiquity weighs 50 gm and shows C^{14} activity of 320 disintegrations per minute. Estimate the length of the time in years which has elapsed since this wood was part of living tree, assuming that living plants show a C^{14} activity of 12 disintegrations per minute per gm. The half life of C^{14} is 5730 yrs.

SUBJECTIVE TYPE

Q19. A radioactive nucleus ${}_zX^A$ emite 3α–particles and 5β–particles. The ratio of number of neutrons to that of protons in the product nucleus will be :–

Q20. An experiment is done to determine the half–life of radioactive substance that emits one β–particle for each decay process. Measurement show that 8.4 β are emitted each second by 2.5 mg of the substance. The atomic weight of the substance is 230. Find the half life of the substance.

Q21. The activity of a sample of radioactive material is A_1 at time t_1 and A_2 at time t_2 ($t_2 > t_1$). Its mean life is T. Find Az.

Q22. U^{238} and U^{235} occur in nature in an atomic ratio 140 : 1. Assuming that at the time of earth's formation the two isotopes were present in equal amounts. Calculate the age of the earth.

(Half life of $u^{238} = 4.5 \times 10^9$ yrs & that of $U^{235} = 7.13 \times 10^8$ yrs)

Q23. 200 MeV of energy can be obtained by per fission. In a reactor generating 1000 kW find the number of nuclei under going the fission per second :-

Q24. The amount of U^{235} to be fissioned, to operate 10 kW nuclear reactor is (Approximately). Assume 200 MeV of energy can be obtained by per fission.

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	A	B	B	C	A	B	B	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
D	C	C	D	B	A	C	A	D	C
21	**22**	**23**	**24**	**25**					
B	D	C	B	C					

Ex-1A

1. B,C,D **2.** B,C **3.** A, C, D **4.** A, B, D **5.** A, C

6. D **7.** A **8.** A,B,D **9.** C **10.** D

11. A **12.** C

13. (A) P, Q; (B) P, R; (C) P, S ; (D) P, Q, R

14. Mass number = 172 and Atomic number = 69

15. $\frac{1}{9}$ **16.** $\frac{26}{27}$ **17.** $\frac{1}{\sqrt{2}}$ **18.** a = 89, b = 234

19. n = 8, n' = 6 **20.** 24000

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	C	C	D	D	D	C	B	B	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	A	C	C	B	C	C	B	D	A
21	**22**								
C	D								

Ex-2A

1. C **2.** A **3.** B,C **4.** B **5.** A

6. A,C **7.** C **8.** A **9.** B **10.** A,D

11. B **12.** B,C **13.** A,B,C **14.** B,D **15.** C

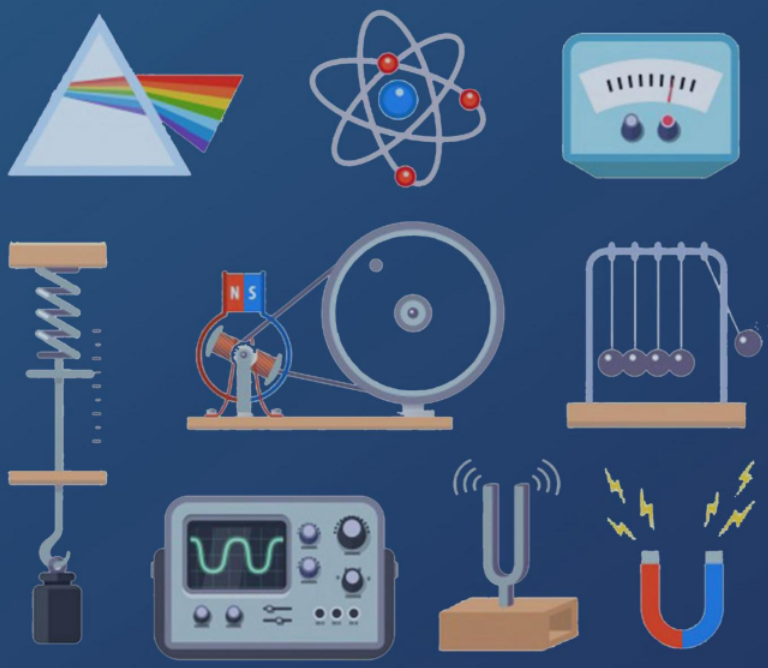
16. A **17.** B **18.** 5196 **19.** $\frac{A-Z-11}{Z-1}$

20. 1.7×10^{10} years **21.** $A_2 = A_1 e^{(t_1-t_2)/T}$ **22.** 6.04×10^9 yrs

23. 3.125×10^{16} **24.** 1.2×10^{-7} gm/s

PHYSICS

Ray Optics



SHEET

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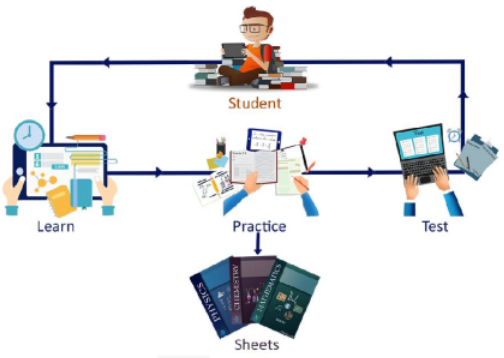
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

S.No	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Introduction and Reflection of Light				
2	Object and Image				
3	Plane mirror	1-3		1-3	
4	Plane Mirrors at an Angle	4	1, 12	4	
5	Introduction to Spherical Mirrors				
6	Paraxial approximation and Focal length				
7	Mirror Equation	5-8			
8	Mirror Equation- Practice	9-12, 13	13		1, 26, 30
9	v-u graphs of Mirrors			5	
10	Newton's Formula	14	2, 9-11, 14		
11	Longitudinal Magnification and Image Velocity	15, 16			2
12	Refraction		3		3
13	Refraction - Practice			6	
14	Apparent Depth	17, 18			4
15	Refraction through Parallel slab			7-8	
16	TIR	19-22		9-10	5, 27, 31
17	TIR Applications and Natural Phenomena	23, 24			
18	Angle of Deviation	25			
19	Refraction through a prism	26			25
20	Minimum and Maximum Angle of Deviation	27-30	19	11-14	6, 14-16
21	Thin prism				
22	Refraction from Curved Surface	31, 32	20	15	7
23	Refraction by lens		15		8
24	Lens Maker's Formula	33, 34	4, 17	16	28, 32
25	Applying Lens Formula	35	5-7	17	
26	Thin Lens - Longitudinal Magnification and Velocity of Image	36	21		29
27	Power of Lens	37-40			33
28	Silvering of Lens			18	
29	Dispersion	41-44		19-20	9-10
30	Human Eye, Defects and its Corrections	45-49		21-22	17-21
31	Simple Microscope	50			34
32	Compound Microscope				
33	Telescope			23	22-24
34	After full Chapter	51	8, 16, 18	24-31	11-13, 35

Plane mirror

Q1. A tall man of height 6 feet, want to see his full image. Then required minimum length of the mirror will be :-

(A) 12 feet (B) 3 feet

(C) 6 feet (D) Any length

Q2. A man runs towards stationary plane mirror at a speed of 15 m/s. What is the speed of his image with respect to mirror :-

(A) 7.5 m/s (B) 15 m/s

(C) 30 m/s (D) 45 m/s

Q3. When a ray of light is incident normally on a plane mirror then the angle of reflection will be :

(A) 0° (B) 90° (C) 180° (D) – 90°

Plane Mirrors at an Angle

Q4. Two plane mirrors are lying perpendicular to each other, there is lamp in between mirrors. Then No. of images of lamp will be :

(A) 3 (B) 4 (C) 5 (D) 6

Mirror Equation

Q5. An object of height 7.5 cm is placed in front of a convex mirror of radius of curvature 25 cm at a distance of 40 cm. The height of the image should be -

(A) 2.3 cm (B) 1.78 cm

(C) 1 cm (D) 0.8 cm

Q6. An object of height 1.5 cm is situated at a distance of 15 cm from a concave mirror. The concave mirror forms its real image of height 3.0 cm. The focal length of concave mirror is-

(A) – 10 cm (B) – 20 cm

(C) 20 cm (D) 30 cm

Q7. If an object is placed 10 cm in front of a concave mirror of focal length 20 cm, the image will be:

(A) Diminished, upright, virtual

(B) Enlarged, upright, virtual

(C) Diminished, inverted, real

(D) Enlarged, upright, real

Q8. A convex mirror has a radius of curvature of 22 cm. If an object is placed 14 cm away from the mirror then its image is formed at -

(A) 6.2 cm on the front side of the mirror.

(B) 6.2 cm on the back side of the mirror.

(C) 51.3 cm on the front of the mirror.

(D) 51.3 cm on the back side of the mirror.

Mirror Equation- Practice

Q9. The focal length of a concave mirror is 12 cm. Where should an object of length 4 cm be placed, so that a real image of 1 cm length is formed ?

(A) 48 cm (B) 3 cm

(C) 60 cm (D) 15 cm

Q10. An object is lying at a distance of 90 cm from a concave mirror of focal length 30 cm. The position and nature of image formed by it will be :

(A) 45 cm, of the size of object

(B) 90 cm, smaller than object

(C) 30 cm, bigger than object

(D) – 45 cm smaller than object

Q11. An object is situated at a distance of 15 cm from a convex mirror of focal length 30 cm. The position from mirror of the image formed by it will be-

(A) – 5 cm (B) 10 cm

(C) – 10 cm (D) + 5 cm

Q12. A virtual image three times the size of the object is obtained with a concave mirror of radius of curvature 36 cm. The distance of the object from the mirror is -

(A) 5 cm (B) 12 cm
(C) 10 cm (D) 20 cm

Q13. The focal length of a concave mirror is 50 cm. Where an object be placed so that its image is two times magnified, real and inverted :-

(A) 75 cm (B) 72 cm
(C) 63 cm (D) 50 cm

Newton's Formula

Q14. A diminished virtual image can be formed only in

(A) Plane mirror
(B) A concave mirror
(C) A convex mirror
(D) Concave- parabolic mirror

Longitudinal Magnification and Image Velocity

Q15. A square wire of side 3 cm is placed at a distance of 25 cm from a concave mirror of focal length 10 cm. The centre of the square is at the axis of the mirror and the plane is normal to the axis. The area enclosed by the image of the wire is -

(A) 4 cm^2 (B) 6 cm^2
(C) 16 cm^2 (D) 36 cm^2

Q16. A point object is moving on the principal axis of a concave mirror of focal length 24 cm towards the mirror. When it is at a distance of 60 cm from the mirror, its velocity is 9 cm/sec. What is the velocity of the image at that instant -

(A) 5 cm/sec. (B) 12 cm/sec
(C) 4 cm/sec (D) 9 cm/sec

Apparent Depth

Q17. Velocity of light in glass, whose refractive index w.r.t. air is 1.5, is 2×10^8 m/s. In a certain liquid the velocity of light is found to be 2.5×10^8 m/s. The refractive index of liquid w.r.t. air is :-

(A) 0.64 (B) 0.80
(C) 1.20 (D) 1.44

Q18. A vessel is half filled with a liquid of refractive index μ. The other half of the vessel is filled with an immiscible liquid of refractive index 1.5μ. The apparent depth of vessel is 50% of the actual depth. The value of μ is :-

(A) 1.6 (B) 1.67
(C) 1.5 (D) 1.4

Total Internal Reflection

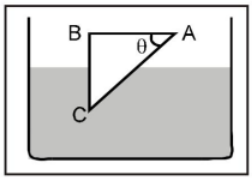
Q19. A point source of light is place 4 m below the surface of water of refractive index 5/3. The minimum diameter of a disc which should be placed over the source on the surface of water to cut-off all light coming out of water is ($\mu = 5/3$)

(A) 2 m (B) 6 m
(C) 4 m (D) 3 m

Q20. The wavelength of light in two liquids 'x' and 'y' is 3500 Å and 7000 Å, then the critical angle for light travelling from x to y will be.

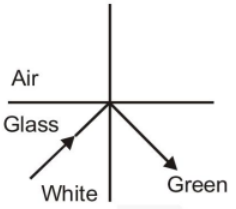
(A) 60° (B) 45°
(C) 30° (D) 15°

Q21. A glass prism ($\mu = 1.5$) is dipped in water ($\mu = 4/3$) as shown in figure. A light ray is incident normally on the surface AB. It reaches the surface BC after totally reflected, if



(A) $\sin\theta \geq 8/9$
(B) $2/3 < \sin\theta < 8/9$
(C) $\sin\theta \leq 2/3$
(D) It is not possible

Q22. White light is incident on the interface of glass and air as shown in the figure. If green light is just totally internally reflected then the emerging ray in air contains :



(A) Yellow, orange, red
(B) Violet, indigo, blue
(C) All colours
(D) All colours except green

TIR Applications and Natural Phenomena

Q23. Which of the following is used in optical fibres
(A) Total internal reflection
(B) Scattering
(C) Diffraction
(D) Refraction

Q24. Brilliance of diamond is due to :-
(A) Scattering
(B) Diffraction
(C) Reflection
(D) Total internal reflection

Angle of Deviation

Q25. A ray is incident at 30° angle on plane mirror. What will be deviation after reflection from mirror.
(A) 120° (B) 60°
(C) 30° (D) 45°

Refraction through a prism

Q26. A ray of light is incident at 60° on a prism of refracting angle 30°. The emerging ray is at an angle 30° with the incident ray. The value of refractive index of the prism is :-

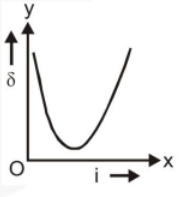
(A) $\frac{\sqrt{3}}{4}$ (B) $\frac{\sqrt{3}}{2}$

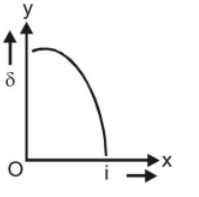
(C) $\sqrt{3}$ (D) $\frac{2}{\sqrt{3}}$

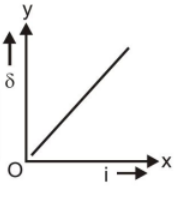
Minimum and Maximum Angle of Deviation

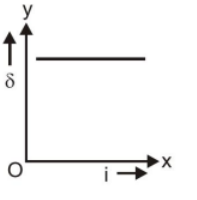
Q27. The angle of the prism is 60° and minimum deviation of 30°, then the angle of incidence for minimum deviation is :-
(A) 30° (B) 45°
(C) 25° (D) 60°

Q28. For a prism, graph between angle of deviation (δ) and angle of incidence will be:-

(A) 

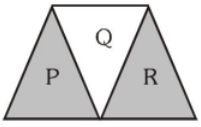
(B) 

(C) 

(D) 

Q29. The angle of minimum deviation measured with a prism is 30° and the angle of prism is 60°. The refractive index of prism material is :-
(A) $\sqrt{2}$ (B) 2
(C) $\frac{3}{2}$ (D) $\frac{4}{3}$

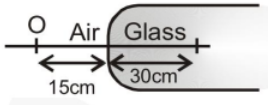
Q30. A given ray of light suffers minimum deviation in an equilateral prism P. Additional prism Q and R of identical shape and of the same material as P are now added as shown in the figure. The ray will suffer:-



(A) Greater deviation
(B) No deviation
(C) Same deviation as before
(D) Total internal reflection

Refraction from Curved Surface

Q31. A point object O is placed in front of a glass rod having spherical end of radius of curvature 30 cm. The image formed would be ..... from spherical end.



(A) 30 cm left
(B) infinity
(C) 1 cm to the right
(D) 18 cm to the left

Q32. A spherical surface of radius of curvature R separates air (refractive index 1.0) from glass (refractive index 1.5). The centre of curvature is in glass. A point object P placed in air is found to have a real image Q in the glass. The line PQ cuts the surface at a point O and PO = OQ. The distance PO is equal to :-

(A) R (B) 3 R (C) 2 R (D) 5 R

Lens Maker's Formula

Q33. Focal length of convex lens is f. If this lens is cut along parallel to its length in two equal parts then focal length of its half part will be :

(A) f/2 (B) f (C) $\frac{3f}{2}$ (D)2f

Q34. The focal length of a convex lens is 10 cm and its refractive index is 1.5. If the radius of curvature of one surface is 7.5 cm, the radius of curvature of the second surface will be :

(A) 7.5 cm (B) 15.0 cm
(C) 75 cm (D) 5.0 cm

Applying Lens Formula

Q35. An object is put at a distance of 15 cm from a convex lens of focal length 10cm.If a real image is formed. Its distance from the lens will be :

(A) 15 cm (B) 20 cm
(C) 25 cm (D) 30 cm

Thin Lens - Longitudinal Magnification and Velocity of Image

Q36. A point object is placed at a distance of 10 cm and its real image is formed at a distance of 20 cm from a convex lens. If the object is moved by 0.1 cm towards the mirror, the image will shift by about.

(A) 0.4 cm away from the lens
(B) 0.4 cm towards the lens
(C) 0.8 cm away from the lens
(D) 0.8 cm towards the lens

Power of Lens

Q37. A convex lens is in contact with concave lens. The magnitude of the ratio of their focal length of convex & concave lens is 2/3. Their equivalent focal length is 30cm. What are their individual focal lengths ?

(A) 50,–75 (B) –10, 15
(C) –50, 75 (D) 10,–15

Q38. Two convex lens of focal length 20 cm and 25 cm are placed in contact with each other, then power of this combination is :-

(A) + 1 D (B) + 9 D
(C) – 1 D (D) – 9 D

Q39. Lenses of powers 3D and -5D are combined to from a compound lens. An object is placed at a distance of 50 cm from this lens. Calculate the position of its image.

(A) -10cm (B) +10cm

(C) -25cm (D) + 25cm

Q40. An equiconvex lens has a power of 5 dioptre. If it is made of glass of refractive index 1.5. then radius of curvature of its each surface will be ?

(A) 20cm (B) 10cm

(C) 40cm (D) ∞

Dispersion

Q41. Rainbow is formed due to :-

(A) Scattering & refraction

(B) Total internal reflection & dispersion

(C) Reflection only

(D) Diffraction and dispersion

Q42. A plane glass slab is kept over various coloured letters; the letter which appears least raised is

(A) blue (B) voilet

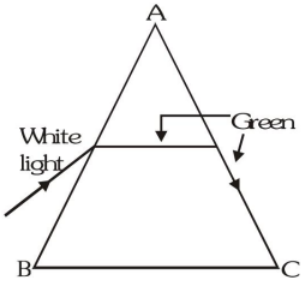
(C) green (D) red

Q43. Prism angle of glass prism is 10°. It's refractive index of red and violet colour is 1.51 and 1.52 respectively. Then its dispersive power will be :

(A) 0.015 (B) 0.020

(C) 0.011 (D) 0.019

Q44. White light is incident on face AB of a glass prism.The path of the green component is shown in the figure. If the green light is just totally internally reflected at face AC as shown, the light emerging from face AC will contain :



(A) yellow, orange and red colours

(B) violet, indigo and blue colours

(C) all colours

(D) all colours except green

Human Eye, Defects and its Corrections

Q45. A person can not see the objects beyond 50 cm. The power of a lens to correct this vision will be-

(A) +2D (B) –2D

(C) +5D (D) 0.5 D

Q46. A person can not see clearly an object kept at a distance beyond of 100 cm. Find the nature and the power of lens to be used for seeing clearly the object at infinity.

(A) 1D (B) – 1D

(C) 2D (D) – 2D

Q47. A person can see clearly only upto a distance of 25 cm. He wants to read a book placed at a distance of 50 cm. What kind of lens does he require for his spectacles and what must be its power?

(A) Concave, – 1.0 D

(B) Convex, + 1.5 D

(C) Concave, – 2.0 D

(D) Convex, + 2.0 D

Q48. A long sighted person has a minimum distance of distinct vision of 50 cm. He wants to reduce it to 25 cm. He should use a:

(A) Concave lens of focal length 50 cm

(B) Convex lens of focal length 25 cm

(C) Convex lens of focal length 50 cm

(D) Concave lens of focal length 25 cm

Q49. To remove myopia (short sightedness) a lens of power 0.66D is required. The distant point of the eye is approximately :

(A) 100 cm (B) 151.5 cm

(C) 50 cm (D) 25 cm

Simple Microscope

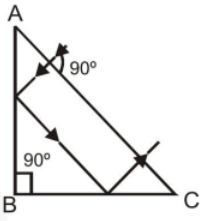
Q50. The focal length of convex lens is 2.5 cm. Its magnifying power for minimum distance of distinctvision will be :-

(A) 25 (B) 52

(C) 11 (D) 1.1

Miscellaneous

Q51. A ray falls on a prism ABC (AB = BC) and travels as shown in figure. The minimum refractive index of the prism material should be :



(A) $\frac{4}{3}$ (B) $\sqrt{2}$

(C) 1.5 (D) $\sqrt{3}$

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. If $\theta = 120°$ then total number of images formed by the mirror system of object not may be :-

(A) 2 (B) 3 (C) 4 (D) 5

Q2. A concave mirror forms an image of the sun at a distance of 12 cm from it.

(A) The radius of curvature of this mirror is 6 cm.

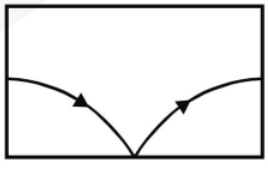
(B) To use it as a shaving mirror, it can be held at a distance of 8-10 cm from the face

(C) If an object is kept at a distance of 24 cm from it, the image formed will be of the same size as the object

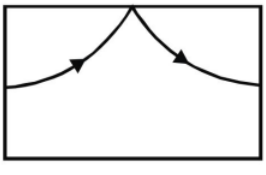
(D) All the above alternatives are correct.

Q3. A cubic container is filled with a liquid whose refractive index increases linearly from top to bottom. Which of the following figures may represent the path of a ray of light inside the liquid?

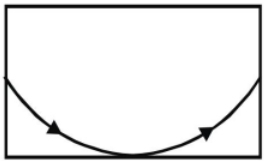
(A)



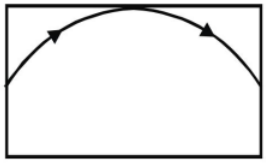
(B)



(C)



(D)



Q4. A lens is formed by a material having refecting index $\frac{3}{2}$ & radii of curvature 20cm & 10 cm. Then choose the correct option(s):-

(A) If lens is concavo-convex & light is falling on the surface having radius of curvature 20 cm, then focal length is 40 cm.

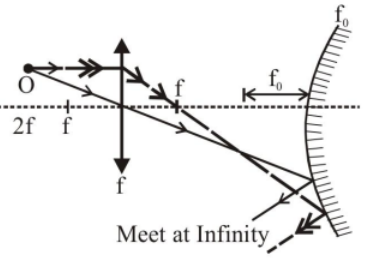
(B) If lens is concavo-convex & light is falling on the surface having radius of curvature 10 cm, then focal length is – 40 cm.

(C) If lens is convexo-concave & light is falling on the surface having radius of curvature 20 cm, then focal length is 40 cm.

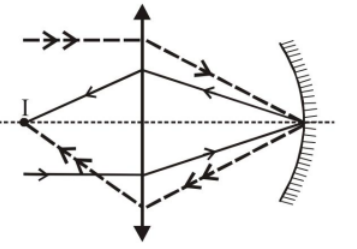
(D) If lens is convexo-concave & light is falling on the surface having radius of curvature 10 cm, then focal length is – 40 cm.

Q5. Choose the incorrect ray diagram(s). All the rays shown are paraxial. [↕ denotes converging lens and | denotes diverging lens] :

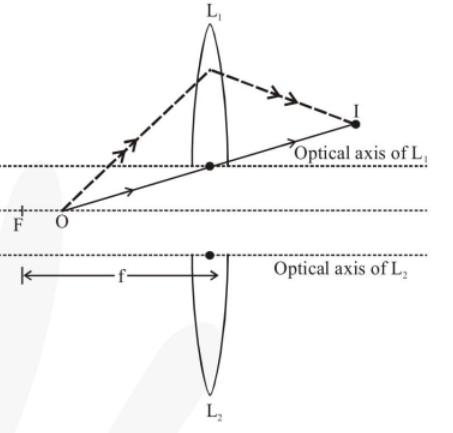
(A)



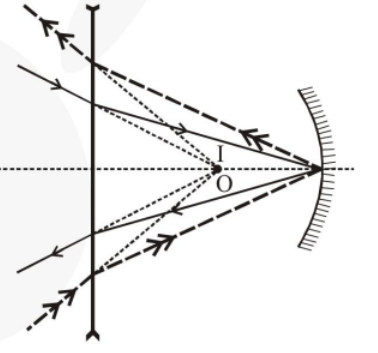
(B)



(C)

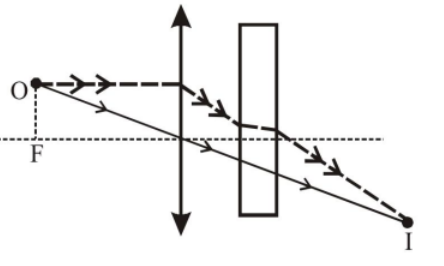


(D)

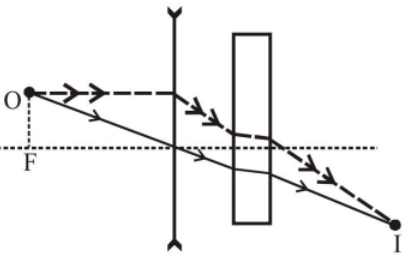


Q6. Choose incorrect ray diagram [↕ denotes converging lens and | denotes diverging lens] All symbols have their usual meaning and all the rays shown are paraxial. (focal length of each lens is F)

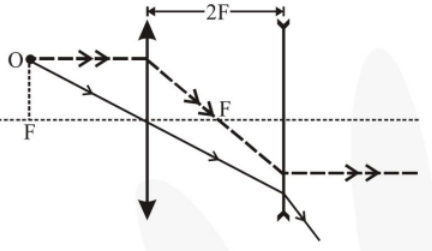
(A)



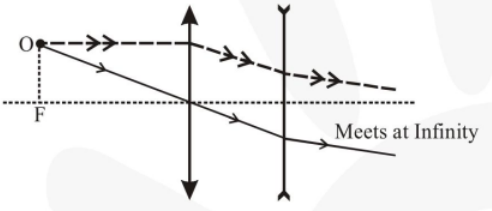
(B)



(C)



(D)



Q7. A man wanted to get a picture of a Zebra. He photographed a white donkey after fitting a glass with black streaks onto the objective of his camera.

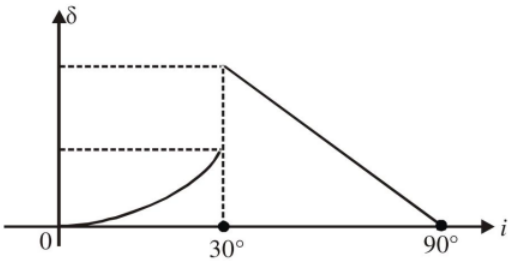
(A) the image will look like a white donkey on the photograph.

(B) the image will look like a Zebra on the photograph.

(C) the image will be more intense compared to the case in which no such glass is used.

(D) the image will be less intense compared to the case in which no such glass is used.

Q8. Figure shows graph of angle of deviation v/s angle of incidence for a light ray. Incident ray goes from medium 1 (μ_1) to medium 2 (μ_2). Mark the **correct** option(s).



(A) $\frac{\mu_1}{\mu_2} = \frac{1}{2}$

(B) Critical angle is 30°

(C) $\mu_1 > \mu_2$

(D) Maximum deviation is 120°

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 9 to 11

A real object is placed perpendicular to the principal axis of a concave mirror at a position (1) such that the image formed is real with a magnification 2. The object is now shifted to another position (2) at a distance 15 cm from the position (1) and a real image is obtained with a magnification 8. Shifting the position of object from (2) to a third position (3) gives an image with magnification 1/2.

Q9. Position of the image when the object is at position (3) is :-

(A) between centre of curvature and ∞

(B) between focus and centre of curvature

(C) at focus

(D) between pole and focus

Q10. Focal length of the mirror is :-

(A) – 60 cm

(B) –40 cm

(C) –30 cm

(D) –25 cm

Q11. Distance of position (1) of the object from pole and that of position (2) of object from pole are , respectively :-

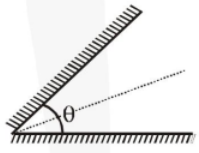
(A) 60 cm, 75 cm (B) 75 cm, 60 cm

(C) 60 cm, 45 cm (D) 45 cm, 30 cm

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q12. Angle between two mirrors 'θ' and location of object is given in column I and some possible number of images are given in column II.



Column –I	Column –II
(A) θ = 30° and object is on bisector	(P) 9
(B) θ = 36° and object is on bisector	(Q) 11
(C) θ = 22.5° and object is on bisector	(R) 5
(D) θ = 72° and object is not on bisector	(S) 15

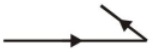
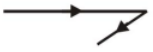
Q13.

Column-I	Column-II
(A) An object is placed at a distance equal to focal length from pole before convex mirror	(P) Maginification is (∞)
(B) An object is placed at focus before a concave mirror	(Q) Magnification is (0.5)
(C) An object is placed at the centre of curvature before a concave mirror.	(R) Magnification is (1/3)
(D) An object is placed at a distance equal to radius of curvature before a convex mirror.	(S) Magnification is (–1)

Q14. An object O is kept perpendicular to the principal axis of a spherical mirror. In column I, coordinate of, object, u with sign in cm, type of mirror and its focal length in cm is given

Column I	Column II
(A) u = –18, concave mirror, 12	(P) Image is real
(B) u = –12, concave mirror, 18	(Q) Image is virtual
(C) u = –8, convex mirror, 10	(R) Image diminished
(D) u = –10, convex mirror, 8	(S) Image is enlarged
	(T) Image is inverted

Q15. Four rays of light parallel and above to optic axis and their path after passing through an optical system are shown in column-I. Match the corresponding optical instrument from column-II :

Column-I	Column-II
(A) 	(P) Convex lens
(B)	(Q) Concave lens
(C)	(R) Convex mirror
(D) 	(S) Concave mirror

Q16. Column–II shows the optical phenomenon that can be associated with optical components kept in air given in column–I. Note that column–I may have more than one matching options in column–II.

Column–I	Column–II
(A) Convex mirror	(P) Dispersion
(B) Converging lens	(Q) Deviation
(C) Thin prism	(R) Real image of real object
(D) Glass slab	(S) Virtual images of real object

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q17. What is the refractive index of material of a plano-convex lens, if the radius of curvature of the convex surface is 10 cm and focal length of the lens is 30 cm ?

Q18. Prism angle of a prism is 10°. Their refractive index for red and violet colour is 1.51 and 1.52 respec tively. Then find the dispersive power.

SUBJECTIVE TYPE

Q19. The angle of minimum deviation for prism of angle $\frac{\pi}{3}$ is $\frac{\pi}{6}$. Calculate the velocity in the material of the prism, if the velocity of light in vacuum is $3 \times 10^8\ ms^{-1}$.

Q20. A beam of light converges towards a point O, behind a convex mirror of focal length 20 cm. Find the nature and position of image if the point O is :-

(a) 10 cm behind the mirror

(b) 30 cm behind the mirror.

Q21. A magnifying lens has a focal length of 10 cm.

(a) Where should the object be placed if the image is to be 30 cm from the lens ?

(b) What will be the magnification ?

SINGLE CORRECT TYPE

Q1. A man on ground of height 170 cm wants to see his complete image in a plane mirror (while standing) . His eyes are at a height of 160 cm from the ground. choose incorrect statement.

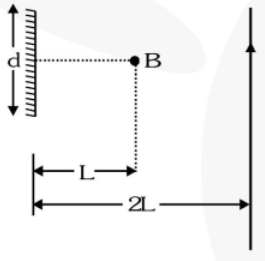
(A) Minimum length of the mirror = 80 cm

(B) Minimum length of the mirror = 85 cm

(C) Bottom of the minimum mirror should be at a height 85 cm from ground.

(D) Top of the minimum mirror should be 5 cm above eye level.

Q2. A point source of light B, placed at a distance L in front of the centre of plane mirror of width d, hangs vertically on a wall. A man walks in front of the mirror along a line parallel to the mirror at a distance 2L from it as shown. The greatest distance over which he can see the image of the light source in the mirror is :



(A) d/2 (B) d

(C) 2d (D) 3d

Q3. A point object approaches a plane mirror with a speed of 10 ms^{-1}, while the image recedes away from the mirror with a speed of 6 ms^{-1} (as seen by stationary observer). The direction and magnitude of the velocity of mirror is :-

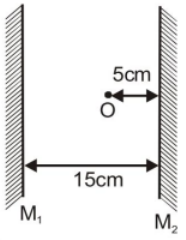
(A) towards the object, 8 ms^{-1}

(B) towards the image, 6 ms^{-1}

(C) away from the object, 8 ms^{-1}

(D) away from the object, 2 ms^{-1}

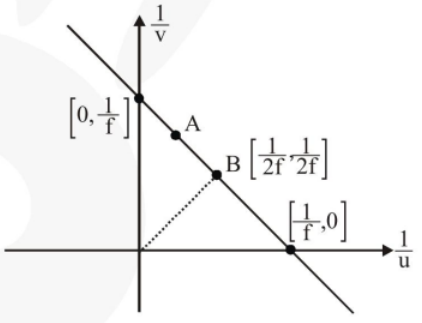
Q4. Figure shows two plane mirrors parallel to each other and an object O placed between them. Then the distance of the first three images from the mirror M_2 will be : (in cm)



(A) 5, 10, 15 (B) 5, 15, 30

(C) 5, 25, 35 (D) 5, 15, 25

Q5. Figure shows $\frac{1}{v}$ vs $\frac{1}{u}$ curve for convex mirror. Nature of image at point A is :-



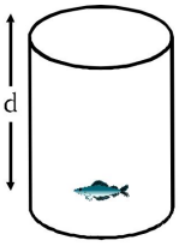
(A) Real, erect, magnified

(B) virtual, inverted, magnified

(C) virtual, inverted, diminished

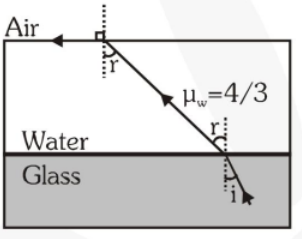
(D) virtual, erect, diminished

Q6. A fish floats in liquid with its eye at the centre of an opaque walled full tank of liquid of circular cross section. When the fish look upwards, it can see a fish-eye view of the surrounding scene i.e. it is able to view the entire space above the liquid surface. The diameter of the tank is 30 cm, and the critical angle for liquid is 37°. At what maximum depth below the surface of the liquid, must the fish be floating? $\left(\sin 37° = \frac{3}{5}\right)$



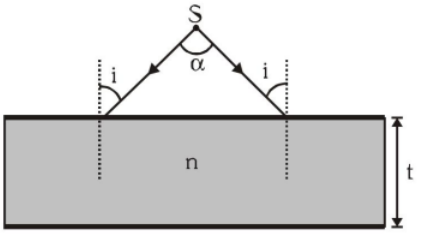
(A) 16 cm (B) 20 cm
(C) 11.25 cm (D) 25 cm

Q7. A ray of light is incident at the glass–water interface at an angle i, it emerges finally parallel to the surface of water, then the value of μ_g would be :-



(A) (4/3) sin i (B) 1/sin i
(C) 4/3 (D) 1

Q8. A diverging beam of light from a point source S having divergence angle α falls symmetrically on a glass slab as shown. The angles of incidence of the two extreme rays are equal. If the thickness of the glass slab is t and its refractive index is n, then the divergence angle of the emergent between them is :



(A) zero (B) α
(C) $\sin^{-1}(1/n)$ (D) $2\sin^{-1}(1/n)$

Q9. A ray of light travelling in water is incident on its surface open to air. The angle of incidence is θ, which is less than the critical angle. Then there will be :-

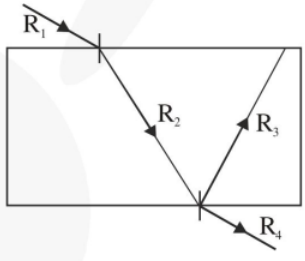
(A) Only a reflected ray and no refracted ray

(B) Only a refracted ray and no reflected ray

(C) A reflected ray and a refracted ray and the angle between them would be less than $180°-2\theta$.

(D) A reflected ray and a refracted ray and the angle between them would be greater than $180° - 2\theta$.

Q10. A ray R_1 is incident on the plane surface of the glass slab (kept in air) of refractive index $\sqrt{2}$ at an angle of incidence equal to the critical angle for this air glass system. The refracted ray R_2 undergoes partial reflection and refraction at the other surface. The angle between reflected ray R_3 and the refracted ray R_4 at that surface is :



(A) 45° (B) 135°
(C) 105° (D) 75°

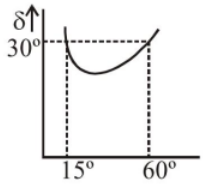
Q11. A ray of light passes through equilateral Prism (μ =1.5) such that angle of incidence is equal to angle of emergence and the later is equal to 3/4th of Prism angle. The angle of deviation is

(A) 60° (B) 30°
(C) 45° (D) 120°

Q12. Three prisms 1,2 and 3 have the prism angle A = 60°, but their refractive indices are respectively 1.4, 1.5 and 1.6.If δ_1, δ_2,δ_3, be their respective angles of deviation then :-

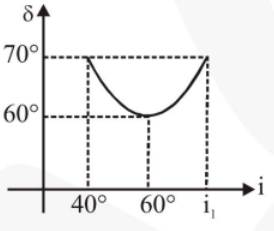
(A) $\delta_3 > \delta_2 > \delta_1$ (B) $\delta_1 > \delta_2 > \delta_3$
(C) $\delta_1 = \delta_2 = \delta_3$ (D) $\delta_2 > \delta_1 > \delta_3$

Q13. Figure shows graph of deviation δ versus angle of incidence for a light ray striking a prism. Angle of prism is :-



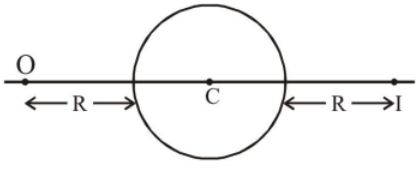
(A) 30°
(B) 45°
(C) 60°
(D) 75°

Q14. The curve of angle of incidence versus angle of deviation shown has been plotted for prism. The value of refractive index of the prism used is :



(A) $\sqrt{3}$
(B) $\sqrt{2}$
(C) $\frac{\sqrt{3}}{\sqrt{2}}$
(D) $\frac{2}{\sqrt{3}}$

Q15. In the given situation, a spherical transparent surface of radius R is placed. The refractive index of sphere is such that image for an object kept at distance R is formed at the same distance of the opposite side. What is refractive index of sphere ?



(A) 1.5
(B) 1.75
(C) 1.25
(D) 2

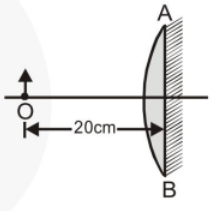
Q16. A concave lens of glass, refractive index 1.5 has both surfaces of same radius of curvature R. On immersion in a medium of refractive index 1.75, it will behave as a :-

(A) convergent lens of focal length 3.5 R
(B) convergent lens of focal length 3.0 R
(C) divergent lens of focal length 3.5 R
(D) divergent lens of focal length 3.0 R

Q17. A plano-convex lens of refractive index 1.5 and radius of curvature 30 cm is silvered at the curved surface. Now, this lens has been used to form the image of an object. At what distance from this lens, an object be placed in order to have a real image of the size of the object?

(A) 20 cm
(B) 30 cm
(C) 60 cm
(D) 80 cm

Q18. A point object is placed at a distance of 20 cm form a thin plano-convex lens of focal length 15 cm. If the plane surface is silvered, the image will from at :



(A) 60 cm from left of AB
(B) 30 cm from left of AB
(C) 12 cm from left of AB
(D) 60 cm from right of AB

Q19. If the refractive indices of crown glass for red, yellow and violet colours are 1.5140, 1.5170 and 1.5318 respectively and for flint glass these are 1.6434, 1.6499 and 1.6852 respectively, then the dispersive powers for crown and flint glass are respectively.

(A) 0.034 and 0.064
(B) 0.064 and 0.034
(C) 1.00 and 0.064
(D) 0.034 and 1.0

Q20. Lenses applied in achromatic combination have dispersive power in ratio of 5:3. If focal length of concave lens is 15cm, then focal length of other lens will be :

(A) -9cm (B) +9cm

(C) -12cm (D)+12 cm

Q21. A myopic person can not see objects lying beyond 2 m. The focal length and power of the lens required to remove this defect will be -

(A) 1 m & 0.5 D (B) – 2 m & – 0.5 D

(C) 0.5 m & 0.5 D (D) – 0.5 m & 0.5 D

Q22. A person's near point is 50 cm and his far point is 3m. Powers of the lenses he required for :

(i) for reading

(ii) for viewing distinct stars

(A) - 2D and 0.33 D (B) 2D and - 0.33 D

(C) - 2D and 3D (D) 2D and - 3 D

Q23. A telescope consisting of objective of focal length 60cm and a single lens eye piece of focal length 5cm is focussed at a distant object in such a way that parallel rays emerge from the eye piece. If the object subtends an angle of 2° at the objective, then angular width of image will be.

(A) 10° (B) 24° (C) 50° (D) 1/6°

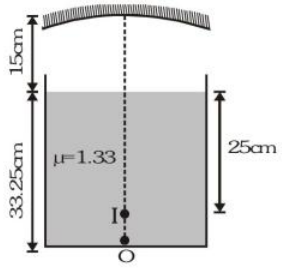
Q24. A container is filled with water (μ = 1.33) upto a height of 33.25 cm. A concave mirror is placed 15cm above the water level and the image of an object placed at the bottom is formed 25cm below the water level. The focal length of the mirror is :-

(A) 10 cm

(B) 15 cm

(C) 18.3 cm

(D) 25 cm



Q25. A plane mirror OA of length 2 m is kept along the line y = –x as shown in the figure.

An insect having velocity of $4\hat{i}$ cm/s is moving along the x-axis from far away. The time span for which the insect can see its image will be :-

(A) 50 sec (B) 25 sec

(C) $25\sqrt{2}$ sec (D) $50\sqrt{2}$ sec

Q26. There is a prism with refractive index equal to $\sqrt{2}$ and the refracting angle equal to 30°. One of the refracting surface of the prism is polished. A beam of monochromatic light will retrace its path if its angle of incidence over the first refracting surface of the prism is -

(A) 0° (B) 30°

(C) 45° (D) 60°

Q27. Figure A shows two identical plano-convex lenses in contact as shown. The combination has focal length 24 cm. Figure B shows the same with a liquid introduced between them. If refractive index of glass of the lenses is 1.50 and that of the liquid is 1.60, the focal length of the system in figure B will be :-

(A) –120 cm (B) 120 cm

(C) –24 cm (D) 24 cm

Q28. The size of the image of an object, which is at infinity, as formed by a convex lens of focal length 30cm is 2cm. If a concave lens of focal length 20cm is placed between the convex lens and the image at a distance of 26cm from the convex lens, calculate the new size of the image :–

(A) 1.25 cm (B) 2.5 cm

(C) 1.05 cm (D) 2 cm

Q29. A glass convex lens (μ_g = 1.5) has a focal length of 8 cm when placed in air. What would be the focal length of the lens when it is immersed in water (μ_w = 1.33)

(A) 2 m (B) 4 cm

(C) 16 cm (D) 32 cm

Q30. A thin Prism P_1 with angle 4° and made from glass of refractive index 1.54 is combined with another thin Prism P_2 made from glass of refractive index 1.72 to produce dispersion without deviation. The angle of Prism P_2 is:-

(A) 5.33° (B) 4°

(C) 3° (D) 2.6°

Q31. Angle of prism is A and its one surface is silvered. Light rays falling at an angle of incidence 2A on first surface return back through the same path after suffering reflection at second silvered surface. Refractive index of the material of prism is:-

(A) 2 sin A (B) 2 cos A

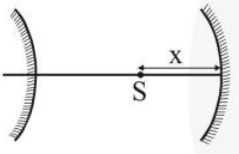
(C) $\frac{1}{2}$ cosA (D) tanA

Exercise - 2A *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A convex mirror and a concave mirror are placed on the same optic axis, separated by distance $L = 20$ cm. The radius of curvature of each mirror has a magnitude of 12 cm. A light source is located at a distance x from the concave mirror as shown in figure.



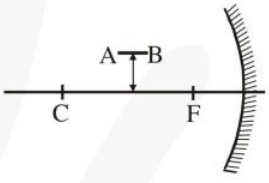
(A) The rays from the source return to the source after reflecting first from the convex mirror and then from the concave mirror for $x = 8$ cm.

(B) The rays from the source return to the source after reflecting first from the convex mirror and then from the concave mirror for $x = 16$ cm.

(C) If the rays from the source return to the source after first reflecting from the concave mirror and then from the convex mirror for $x = 8$ cm.

(D) If the rays from the source return to the source after first reflecting from the concave mirror and then from the convex mirror for $x = 16$ cm.

Q2. An object AB is placed parallel and close to the optical axis between focus F and centre of curvature C of a converging mirror of focal length f as shown in figure.



(A) Image of A will be closer than that of B from the mirror.

(B) Image of AB will be parallel to the optical axis.

(C) Length of image is equal to AB.

(D) Length of image is more than AB.

Q3. When a ray of light of frequency 6×10^{14} Hz travels from water of refractive index 4/3 to the glass of refractive index 8/5, its :-

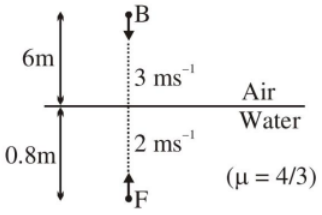
(A) frequency decreases to 5/6 of its initial value

(B) speed decreases to 5/6 of its initial value

(C) wavelength decreases to 5/6 of its initial value

(D) speed increases to 6/5 of its initial value

Q4. A fish, F in the pond, is at a depth of 0.8 m from water surface and is moving vertically upwards with velocity 2 ms^{-1}. At the same instant, a bird B is at a height of 6 m from water surface and is moving downwards with velocity 3 ms^{-1}. At this instant both are on the same vertical lines as shown in the figure. Which of the following statement(s) is(are) correct?



(A) Height of B, observed by F (from itself) is equal to 8.00 m.

(B) Depth of F, observed by B (from itself) is equal to 6.60 m.

(C) Velocity of B, observed by F (relative to itself) is equal to 5.00 ms^{-1}.

(D) Velocity of F, observed by B (relative to itself) if equal to 4.50 ms^{-1}.

Q5. In the figure (a) light is incident at an angle θ which is slightly greater than the critical angle. Now, keeping the incident fixed a slab of refractive index n_3 is placed on surface AB in fig. (b). Which of the following statements are correct :

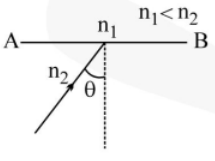


Fig. (a)

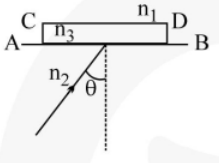


Fig. (b)

(A) Total internal reflection occurs at AB for $n_3 < n_1$

(B) Total internal reflection occurs at AB for $n_3 > n_1$

(C) The ray will return back to the same medium for all values of n_3

(D) Total internal reflection occurs at CD for $n_3 < n_1$

Q6. For the refraction of light through a prism

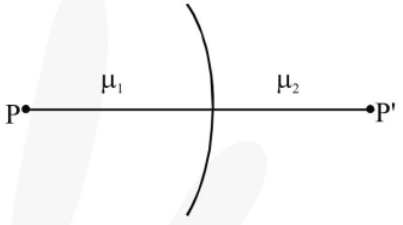
(A) For every angle of deviation there are two angles of incidence.

(B) The light travelling inside an equilateral prism is necessarily parallel to the base when prism is set for minimum deviation.

(C) There are two angles of incidence for maximum deviation.

(D) Angle of minimum deviation will increase if refractive index of prism is increased keeping the outside medium unchanged if $\mu_{Prism} > \mu_{Surrounding}$.

Q7. Two refracting media are separated by a spherical interface as shown in the figure. *PP'* is the principal axis, μ_1 and μ_2 are the refractive indices of medium of incidence and medium of refraction respectively, then:-



(A) if $\mu_2 > \mu_1$, then there cannot be a real image of real object.

(B) if $\mu_2 > \mu_1$, then there cannot be a real image of virtual object.

(C) if $\mu_1 > \mu_2$, then there cannot be a virtual image of virtual object.

(D) if $\mu_1 > \mu_2$, then there cannot be a real image of real object.

Q8. Optical axis of a thin equi-convex lens is the X-axis. The co-ordinate of a point object and its image are (–20 cm, 1 cm) and (25 cm, –2 cm) respectively :

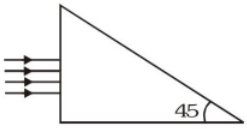
(A) The lens is located at x = 5 cm

(B) The lens is located at x = –5 cm

(C) The focal length of the lens is 10 cm

(D) The focal length of the lens is 15 cm

Q9. A beam of light consisting of red, green and blue and is incident on a right angled prism. The refractive index of the material of the prism for the above red, green and blue wavelengths are 1.39, 1.44 and 1.47 respectively. The prism will



(A) Separate part of the red color from the green and blue colors

(B) Separate part of the blue color from the red and green colors

(C) Separate all the three colors from the other two colors

(D) Not separate even partially, any colors from the other two colors

Q10. Chromatic aberration will be absent if for two thin lenses in contact :-

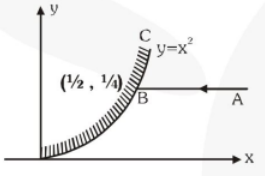
(A) $(\omega_1/f_1) + (\omega_2/f_2) = 0$

(B) $(\omega_1/f_2) + (\omega_2/f_1) = 0$

(C) $(f_1/\omega_2) + (f_2/\omega_1) = 0$

(D) $(\omega_1/\omega_2) + (f_1 + f_2) = 0$

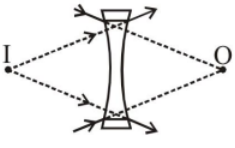
Q11. In the given figure, incident ray AB is parallel to x-axis. The angle of reflection is:-

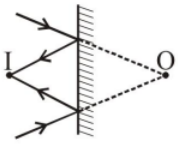


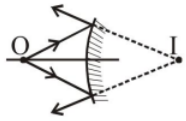
(A) 30° (B) 60°

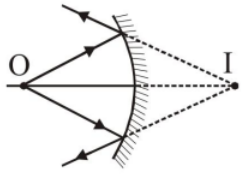
(C) 45° (D) None of these

Q12. The nature of object and image given with each of the optical condition is shown. Choose the **correct** option(s) :-

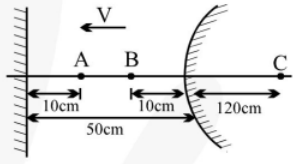
(A) Virtual image  Virtual object

(B) Virtual image  Real object

(C) Real object  Virtual image

(D) Real object  Virtual image

Q13. In the figure shown consider the first reflection at the plane mirror and second at the convex mirror. AB is object.



(A) The second image is real, inverted of $1/5^{th}$ magnification w.r.t AB

(B) The second image is virtual and erect with magnification1/5 w.r.t AB

(C) The second image moves towards the convex mirror

(D) The second image moves away from the convex mirror.

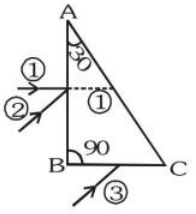
PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 14 to 16

ABC is a right-angled prism kept in air. A ray (1) is incident on the face AB along the normal. Refractive index of the material of prism is the value that will be required so that ray (1) grazes the face AC.

Another ray (2) is incident on the face AB such that it emerges from face AC along the normal to AC. A third ray (3) falls on the face BC and emerges from face AC such that its angle of emergence is the same as that of incidence. Assuming light (1), (2) and (3) to have the same frequency, answer the following questions.



Q14. Refractive index of the material of prism is:-

(A) $\sqrt{2}$ (B) 2

(C) 1.5 (D) 2.2

Q15. Angle of incidence of ray (2) is :-

(A) 0° (B) 45°

(C) 60° (D) 90°

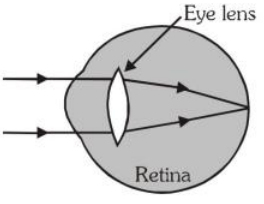
Q16. Deviation suffered by ray (3) is :-

(A) 60° (B) 30°

(C) 90° (D) 120°

Paragraph for Question No. 17 to 21

The ciliary muscles of eye control the curvature of the lens in the eye and hence can alter the effective focal length of the system. When the muscles are fully relaxed, the focal length is maximum. When the muscles are strained the curvature of lens increases (that means radius of curvature decreases) and focal length decreases. For a clear vision the image must be on retina. The image distance is therefore fixed for a clear vision and it equals the distance of retina from eye–lens. It is about 2.5 cm for a grown–up person.



A person can theoretically have clear vision of objects situated at any large distance from the eye. The smallest distance at which a person can clearly see is related to minimum possible focal length. The ciliary muscles are most strained in this position. For an average grown up person minimum distance of object should be around 25 cm.

A person suffering from eye defects uses spectacles (Eye glass). The function of lens of spectacles is to form the image of the objects within the range in which person can see clearly. The image of the spectacle–lens becomes object for eye–lens and whose image is formed on retina.

The number of spectacle–lens used for the remedy of eye defect is decided by the power of the lens required and the number of spectacle–lens is equal to the numerical value of the power of lens with sign. For example power of lens required is +3D (converging lens of focal length $\frac{100}{3}$ cm) then number of lens will be +3).

For all the calculations required you can use the lens formula and lens maker's formula. Assume that the eye lens is equiconvex lens. Neglect the distance between eye lens and the spectacle lens.

Q17. Minimum focal length of eye lens of a normal person is :

(A) 25 cm (B) 2.5 cm

(C) $\frac{25}{9}$ cm (D) $\frac{25}{11}$ cm

Q18. Maximum focal length of eye lens of normal person is:

(A) 25 cm (B) 2.5 cm

(C) $\frac{25}{9}$ cm (D) $\frac{25}{11}$ cm

Q19. A near–sighted man can clearly see object only upto a distance of 100 cm and not beyond this. The number of the spectacles lens necessary for the remedy of this defect will be:

(A) + 1 (B) –1

(C) + 3 (D) –3

Q20. A farsighted man cannot see object clearly unless they are at least 100 cm from his eyes. The number of the spectacles lens that will make his range of clear vision equal to an average grown up person

(A) + 1 (B) –1

(C) + 3 (D) –3

Q21. A person who can see object clearly from distance 10 cm to ∞, then we can say that the person is:

(A) Normal sighted person

(B) Near–sighted person

(C) Far–sighted person

(D) A person with exceptional eye having no eye defect

Paragraph for Question No. 22 to 24

Q22. If an astronomical telescope has objective and eye-pieces of focal lengths 200 cm and 4 cm respectively, then the magnifying power of the telescope for the normal vision is :-

(A) 42 (B) 50 (C) 58 (D) 204

Q23. In the above question the length of the telescope for normal vision, is :-

(A) 204 cm (B) 200 cm

(C) 196 cm (D) 203.45 cm

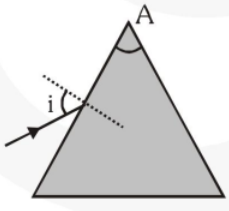
Q24. In the above question magnifying power of the telescope for distinct vision is :-

(A) 42 (B) 50 (C) 58 (D) 204

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q25. For a prism of refracting angle A and refractive index 2. Assume rays are incident at all angles of incidence $0° \le i \le 90°$. Ignore partial reflection.



Column–I	**Column–II**
(A) A = 15°	(P) All rays are reflected back from the second surface.
(B) A = 45°	(Q) All rays are refracted into air from the second surface
(C) A = 70°	(R) Some rays are reflected back from second surface
(D) A = 50°	(S) Some rays are refracted into air from the second surface

NUMERICAL TYPE

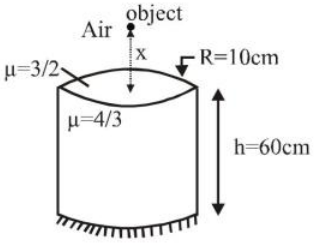
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q26. A concave mirror of focal length 10 cm and convex mirror of focal length 15 cm are placed facing each other 40 cm apart. A point object is placed between the mirror on their commen axis and 15 cm from the concave mirror. Find the position of image produced by the reflection first at concave mirror and then at convex mirror.

Q27. A pin is placed 10 cm in front of a convex lens of focal length 20 cm, made of material having refractive index 1.5. The surface of the lens farther away from the pin is silvered and has a radius of curvature 22 cm. Determine the position of the final image. Is the image real or virtual ?

Q28. A glass convex lens of refractive index $\frac{3}{2}$ has got a focal length equal to 0.3 m. Find the focal length of the lens if it is immersed in water of refractive index $\frac{4}{3}$.

Q29. In the arrangement shown given that a biconvex lens of radius of curvature equal to 10 cm and concave mirror has focal length equal to 20cm. Then find the distance 'x' such that the final image formed by the system coincides with the object.



SUBJECTIVE TYPE

Q30. A object is placed in front of a convex mirror at a distance of 50 cm. A plane mirror is introduced covering the lower half of the convex mirror. If the distance between the object and the plane mirror is 30 cm, it is found that there is no parallax between the images formed by the two mirrors. What is the radius of curvature of the convex mirror? Also calculate magnification produced by convex mirror.

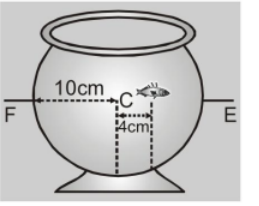
Q31. A ray of light from a denser medium strikes a rarer medium at an angle of incidence i. If the reflected and refracted rays are mutually perpendicular to each other, what is the value of critical angle ?

Q32. A beam of light converges to a point P. A lens is placed in the path of the convergent beam 12 cm from P. At what point does the beam converge if the lens is :-
(a) a convex lens of focal length 20 cm.
(b) a concave lens of focal length 16 cm.

Q33. A 20 cm thick glass slab of refractive index 1.5 is kept infront of a plane mirror. An object is kept in air at a distance 40 cm from the mirror. Find the position of image relative to mirror. What is effect of separation between glass slab and the mirror on image.

Q34. A man with normal near point 25 cm reads a book with small print using a magnifying glass, a thin convex lens of focal length 5 cm.
(a) What is the closest and fartest distance at which he can read the book when viewing through the magnifying glass?
(b) What is the maximum and minimum magnifying power possible using the above simple microscope ?

Q35. In a thin spherical fish bowl of radius 10 cm filled with water of refractive index $\left(\frac{4}{3}\right)$, there is a small fish at a distance 4 cm from the centre C as shown in Figure. Where will the fish appear to be, if seen from (a) E and (b) F (neglect the thickness of glass) ?



Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	B	A	A	B	A	B	B	C	D
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	B	A	C	A	C	C	B	B	C
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	A	A	D	A	C	B	A	A	C
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
A	D	D	B	D	A	D	B	C	A
41	**42**	**43**	**44**	**45**	**46**	**47**	**48**	**49**	**50**
B	D	D	A	B	B	C	C	B	C
51									
B									

Ex-1A

1. A,B **2.** B,C **3.** A,D **4.** A,D **5.** A,B,C

6. A,B,C,D **7.** A,D **8.** A,B,D **9.** B **10.** B

11. C

12. (A) → (Q), (B) → (P), (C) → (S), (D) → (R)

13. (A)–Q; (B)–P; (C)–S; (D)–R

14. (A)→(P,S,T);(B)→(Q,S);(C)→(Q, R) (D)→(Q, R)

15. (A)–R; (B)–Q; (C)–P; (D)–S

16. (A)–Q, S (B)–P,Q,R,S (C)–P,Q,S (D)–S

17. 1.33 **18.** 0.02. **19.** 2.12×10^8 ms^{-1}

20. (a) v = –20 cm, $m = -\left[-\frac{20}{10}\right] = +2$ (b) v = +60 cm, $m = -\left[+\frac{60}{30}\right] = -2$

21. (a) 7.5 cm (b) $m = \left[\frac{h_2}{h_1}\right] = \frac{v}{u} = \frac{-30}{-7.5} = 4$

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	D	A	C	C	B	B	B	C	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	A	B	A	D	A	A	C	A	B
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
B	B	B	C	D	C	A	B	D	C
31									
B									

Ex-2A

1. A,C **2.** A,D **3.** B,C **4.** B,D **5.** A,C

6. B,C,D **7.** A,C **8.** B,C **9.** A **10.** A

11. C **12.** A,C,D **13.** B,C **14.** B **15.** D

16. D **17.** D **18.** B **19.** B **20.** C

21. D **22.** B **23.** A **24.** C

25. (A)–Q, (B)–R,S (C)–P (D)–R, S

26. 6 cm **27.** 11 cm **28.** 1.2 m **29.** 22.5 cm

30. $R = 2f = 25$ cm, $m = +\left[\frac{1}{5}\right]$ **31.** $\theta_C = \sin^{-1}\left[\frac{1}{\cot i}\right] = \sin^{-1}(\tan i)$

32. (a) $v = \frac{60}{8} = 7.5$ cm (b) $v = 48$ cm

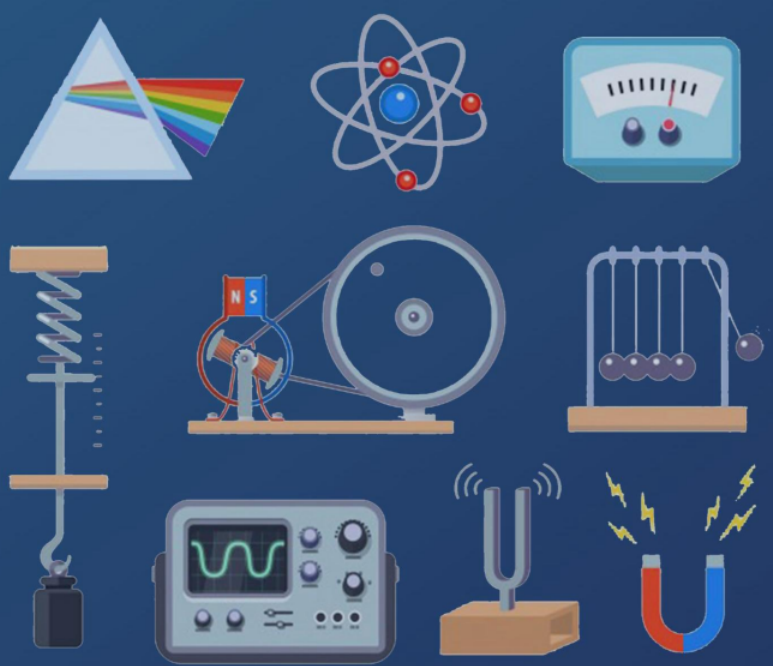
33. 11 cm, Real

34. (a) $(MP)_{min} = \frac{-25}{-5} = 5$ (b) $(MP)_{max} = \frac{-25}{-(25/6)} = 6$

35. (a) 5.3 cm (b) 16.154 cm

PHYSICS

Rotational Motion



SHEET

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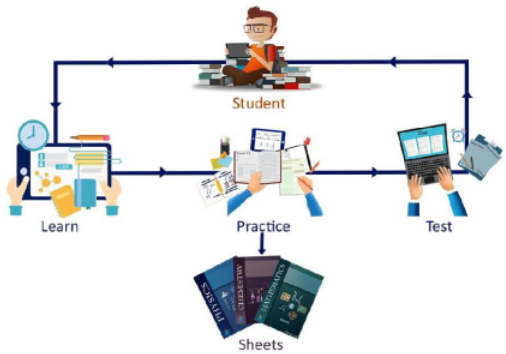
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Introduction		8,9		
2	Kinematics of Pure Rotational Motion	1,2,3			
3	Moment of Inertia	4	10,11,12, 13,14	1	
4	Perpendicular Axis Theorem	5,6,7,8,9	1		
5	Parallel Axis Theorem	10,11,12, 13,14		2	1,2,3,24-29,37
6	Torque	15			
7	Equilibrium			3,4,5	4
8	Torque about an Axis	18		6	5
9	Inertial Pulley			7	
10	Work Energy Theorem		15,16		
11	Angular Momentum	19,20,21	2,17	8,9,10,11	
12	Angular Momemtum Conservation	22,23,24, 25,26,27	18,19	12,13,14	6,7,8
13	Collision	28		15,16	38
14	Toppling			17,18	9
15	CRTM				10
16	Rolling		5	19,20,21, 22, 23	11,39
17	Dynamics of CRTM			24,25,26,27 ,28,29,30	12,13,14,15
18	Kinetic Energy in CRTM	29	6,7	31,32,33,34	16,30,31,36
19	Angular Momentum in CRTM	30	3,4	35	17,18,19, 20,21,40
20	ICOR,IAOR	31			41
21	Cross Product	32,33			
22	After Full Chapter			36,37	22,23,32-35

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Kinematics of Pure Rotational Motion

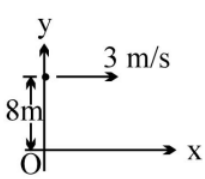
Q.1 Two gear wheels which are meshed together have radii of 0.50 cm and 0.15 cm. The number of revolutions does the smaller turns when the larger turns through 3 revolution is

(A) 5 revolution
(B) 20 revolution
(C) 1 revolution
(D) 10 revolution

Q.2 The rotating rod starts from rest and acquires a rotational speed n = 600 revolution/minute in 2 seconds with constant angular acceleration. The angular acceleration of the rod is

(A) 10 π rad/s^2
(B) 5 π rad/s^2
(C) 15 π rad/s^2
(D) None of these

Q.3 A particle starts from the point (0m, 8m) and moves with uniform velocity of $3\hat{i}$ m/s. After 5 seconds, the angular velocity of the particle about the origin will be :

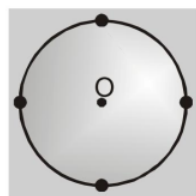


(A) $\frac{8}{289}$ rad/s (B) $\frac{3}{8}$ rad/s
(C) $\frac{24}{289}$ rad/s (D) $\frac{8}{17}$ rad/s

Moment of Inertia

Q.4 Four similar point masses (each of mass m) are placed on the circumference of a disc of mass M and radius R. The M.I. of the system about the normal axis through the centre O will be:-

(A) $MR^2 + 4mR^2$
(B) $\frac{1}{2}MR^2 + 4mR^2$
(C) $MR^2 + \frac{8}{5}mR^2$
(D) none of these



Perpendicular Axis Theorem

Q.5 Three thin uniform rods each of mass M and length L are placed along the three axis of a cartesian coordinate system with one end of each rod at the origin. The M. I. of the system about z-axis is -

(A) $\frac{ML^2}{3}$ (B) $\frac{2ML^2}{3}$
(C) $\frac{ML^2}{6}$ (D) ML^2

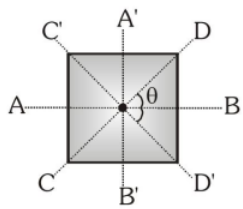
Q.6 By the theorem of perpendicular axes, if a body be in X-Z-plane then :-

(A) $I_x - I_y = I_z$ (B) $I_x + I_z = I_y$
(C) $I_x + I_y = I_z$ (D) $I_y + I_z = I_x$

Q.7 The axis X and Z in the plane of a disc are mutually perpendicular and Y-axis is perpendicular to the plane of the disc. If the moment of inertia of the body about X and Y axes is respectively 30 kg m^2 and 40 kg m^2 then M.I. about Z-axis in kg m^2 will be:-

(A) 70 (B) 50
(C) 10 (D) Zero

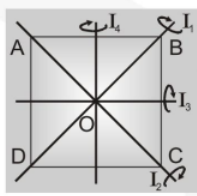
Q.8 Let I be the moment of inertia of a uniform square plate about an axis AB that passes through its centre and is parallel to two of its sides. CD is a line in the plane of the plate that passes through the centre of the plate and makes an angle θ with AB. The moment of inertia of the plate about the axis CD is then equal to:-



(A) I (B) $I\sin^2\theta$

(C) $I\cos^2\theta$ (D) $I\cos^2\left(\frac{\theta}{2}\right)$

Q.9 The moment of inertia of a thin square plate ABCD of uniform thickness about an axis passing through its centre and perpendicular to its plane will be :-



(A) $I_1 + I_2$ (B) $I_1 - I_3$

(C) $I_1 + I_2 + I_4$ (D) $I_1 + I_2 + I_3$

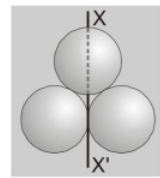
Parallel Axis Theorem

Q.10 The moment of inertia of a uniform circular disc of radius 'R' and mass 'M' about an axis passing from the edge of the disc and normal to the disc is-

(A) $\frac{1}{2}MR^2$ (B) $\frac{7}{2}MR^2$

(C) $\frac{3}{2}MR^2$ (D) MR^2

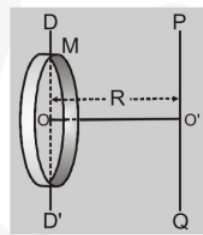
Q.11 Three solid spheres of mass M and radius R are shown in the figure. The moment of inertia of the system about XX' axis will be:-



(A) $\frac{7}{2}MR^2$ (B) $\frac{14}{5}MR^2$

(C) $\frac{16}{5}MR^2$ (D) $\frac{21}{5}MR^2$

Q.12 The moment of inertia of a ring of mass M and radius R about PQ axis will be :-



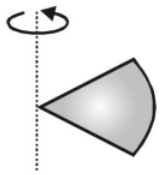
(A) MR^2 (B) $\frac{MR^2}{2}$

(C) $\frac{3}{2}MR^2$ (D) $2MR$

Q.13 The moment of inertia of a thin uniform rod of mass M and length ℓ about an axis perpendicular to the rod through its centre is I. The moment of inertia of the rod about an axis perpendicular to the rod through its end point is-

(A) $\frac{I}{4}$ (B) $\frac{I}{2}$ (C) 2I (D) 4I

Q.14 One quarter section is cut from a uniform circular disc of radius R. This section has a mass M. It is made to rotate about a line perpendicular to its plane and passing through the centre of the original disc. Its moment of inertia about the axis of rotation is :-



(A) $\frac{1}{2}MR^2$ (B) $\frac{1}{4}MR^2$

(C) $\frac{1}{8}MR^2$ (D) $\sqrt{2}MR^2$

Torque

Q.15 A wheel having moment of inertia 2 kg–m^2 about its vertical axis, rotates at the rate of 60 rpm about the axis. The torque which can stop the wheel's rotation in one minute would be :-

(A) $\frac{\pi}{12}$N–m (B) $\frac{\pi}{15}$N–m

(C) $\frac{\pi}{18}$N–m (D) $\frac{2\pi}{15}$N–m

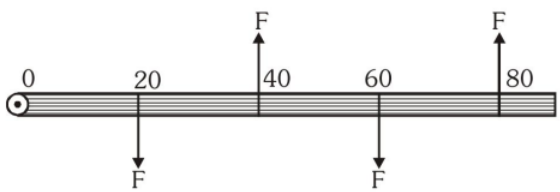
Equilibrium

Q.16 A door 1.6 m wide requires a force of 1 N to be applied at the free end to open or close it. The force that is required at a point 0.4 m distant from the hinges for opening or closing the door is :-

(A) 1.2 N (B) 3.6 N

(C) 2.4 N (D) 4 N

Q.17 Four equal and parallel force are acting on a rod (as shown in figure at distances of 20 cm, 40 cm, 60 cm and 80 cm respectively from one end of the rod. Under the influence of these forces the rod .



(A) is at rest

(B) experiences a torque

(C) experiences a linear motion

(D) Experiences a torque and also a linear motion

INERTIAL PULLEY

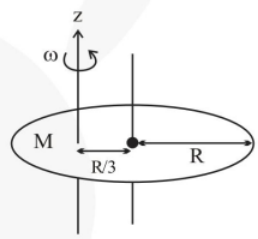
Q.18 A constant torque of 1000 N-m turns a wheel of moment of inertia 200 kg-m^2 about an axis thorugh its centre. Its angular velocity after 3 seconds is- (in rad/sec.)

(A) 1 (B) 5

(C) 15 (D) 10

ANGULAR MOMENTUM

Q.19 Find the angular momentum of a disc about the z-axis.



(A) $\left(\frac{11MR^2}{18}\right)\omega$ (B) $\left(\frac{10MR^2}{18}\right)\omega$

(C) $\left(\frac{11MR^2}{9}\right)\omega$ (D) $\left(\frac{10MR^2}{9}\right)\omega$

Q.20 A particle of mass m is rotating in a plane in a circular path of radius r. Its angular momentum is L. The centripetal force acting on the particle is

(A) $\frac{L^2}{mr}$ (B) $\frac{L^2m}{r}$

(C) $\frac{L^2}{mr^2}$ (D) $\frac{L^2}{mr^3}$

Q.21 When a mass is rotating in a plane about a fixed point, its angular momentum is directed along

(A) the radius

(B) the tangent to orbit

(C) line at an angle of 45° to the plane of rotation

(D) the axis of rotation

Angular Momemtum Conservation

Q.22 A dancer on ice spins faster, when she folds her arms. This is due to

(A) increase in energy and increase in angular momentum

(B) decrease in friction at the skates

(C) constant angular momentum and increase in kinetic energy

(D) increase in kinetic energy and decrease in angular momentum.

Q.23 If the earth were to suddenly contract to $\frac{1}{n}$th of its present radius without any change in its mass then the duration of the new day will be nearly-

(A) $\frac{24}{n}$ hour (B) 24n hour

(C) $\frac{24}{n^2}$ hour (D) $24n^2$ hour

Q.24 A particle undergoes uniform circular motion. About which point on the plane of the circle, will the angular momentum of the particle remain conserved ?

(A) Centre of circle

(B) On the circumference of the circle

(C) Inside the circle

(D) Outside the circle

Q.25 A child is standing with folded hands at the centre of a platform rotating about its central axis. The kinetic energy of the system is K and moment of inertia is I. The child now stretches his arms so that the moment of inertia of the system doubles. The kinetic energy of the system now is :-

(A) 2K (B) $\frac{K}{2}$ (C) $\frac{K}{4}$ (D) 4K

Q.26 A circular turn table has a block of ice placed at its centre. The system rotates with an angular speed ω about an axis passing through the centre of the table. If the ice melts on its own without any evaporation, the speed of rotation of the system-

(A) becomes zero

(B) remains constant at the same value ω

(C) increases to value greater than ω

(D) decreases to a value less than ω

Q.27 A thin circular ring of mass M and radius 'r' is rotating about its axis with a constant angular velocity ω. Four objects each of mass m, are kept gently to the opposite ends of two perpendicular diameters of the ring. The angular velocity of the ring will be-

(A) $\frac{M\omega}{4m}$ (B) $\frac{M\omega}{M+4m}$

(C) $\frac{(M+4m)\omega}{M}$ (D) $\frac{(M+4m)\omega}{M+4m}$

Collision

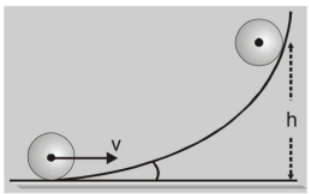
Q.28 A mass m is moving at speed v perpendicular to a rod of length d and mass $M = 6m$ which pivots around a frictionless axle running through its centre. It strikes and sticks to the end of the rod. The moment of inertia of the rod about its centre is $Md^2/12$. Then the angular speed of the system right after the collision is

(A) 2v/d (B) 2v/3d

(C) v/d (D) 3v/2d

Kinetic Energy in CRTM

Q.29 A disc of mass M and radius R rolls on a horizontal surface and then rolls up an inclined plane as shown in the figure. If the velocity of the disc is v, the height to which the disc will rise will be :-

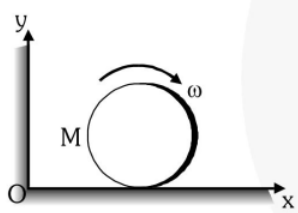


(A) $\frac{3v^2}{2g}$ (B) $\frac{3v^2}{4g}$

(C) $\frac{v^2}{4g}$ (D) $\frac{v^2}{2g}$

Angular Momentum in CRTM

Q.30 A disc of mass M and radius R is rolling with angular speed ω on a horizontal plane as shown. The magnitude of angular momentum of the disc about the origin O is:-

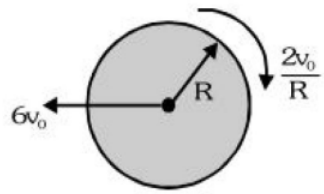


(A) $\left(\frac{1}{2}\right)MR^2\omega$ (B) $MR^2\omega$

(C) $\left(\frac{3}{2}\right)MR^2\omega$ (D) $2MR^2\omega$

ICOR, IAOR

Q.31 A disc of radius R = 2m moves as shown in the figure, with a velocity of translation of $6v_0$ of its centre of mass and an angular velocity of $\frac{2v_0}{R}$. The distance (in m) of instantaneous axis of rotation from its centre of mass is -



(A) 3 (B) 4

(C) 5 (D) 6

Cross Product

Q.32 $\vec{A} = 30\hat{i}$, $\vec{B} = 40\hat{k}$ then $\vec{A} \times \vec{B}$ = ?

(A) $1200\hat{i}$ (B) $1200\hat{j}$

(C) $-1200\hat{j}$ (D) $1200\hat{k}$

Q.33 $\vec{A} = 2\hat{i} + 4\hat{j} - \hat{k}$, $\vec{B} = 4\hat{j} + 3\hat{k}$

then $\vec{A} \times \vec{B}$ =?

(A) $16\hat{i} - 6\hat{j} - 8\hat{k}$

(B) $16\hat{i} + 6\hat{j} - 8\hat{k}$

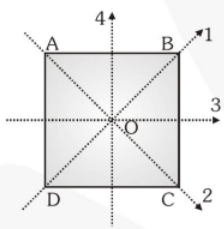
(C) $16\hat{i} - 6\hat{j} + 8\hat{k}$

(D) None of These

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q.1 The moment of inertia of a thin square plate ABCD, of uniform thickness about an axis passing through the centre O and perpendicular to the plane of the plate is (where I_1, I_2, I_3 and I_4 are respectively moments of inertia about axis 1, 2, 3 and 4 which are in the plane of the plate)

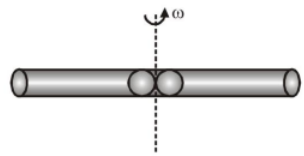


(A) $I_1 + I_2$ (B) $I_3 + I_4$
(C) $I_1 + I_3$ (D) $I_1 + I_2 + I_3 + I_4$

Q.2 A particle falls freely near the surface of the earth. Consider a fixed point O (not vertically below the particle) on the ground

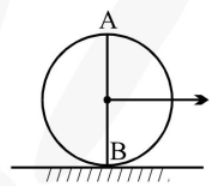
(A) Angular momentum of the particle about O is increasing.
(B) Torque of the gravitational force on the particle about O is decreasing.
(C) The moment of inertia of the particle about O is decreasing.
(D) The angular velocity of the particle about O is increasing.

Q.3 A smooth tube of certain mass is rotated in gravity free space and released. The two balls shown in the figure move towards ends of the tube. For the whole system which of the following quantity is not conserved :-



(A) Angular momentum
(B) Linear momentum
(C) Kinetic energy
(D) Angular speed

Q.4 A uniform disc is rolling on a horizontal surface. At a certain instant B is the point of contact and A is at height 2R from ground, where R is radius of disc.

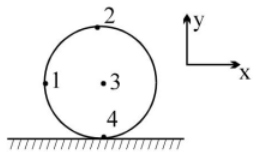


(A) The magnitude of the angular momentum of the disc about B is thrice that about A.
(B) The angular momentum of the disc about A is anticlockwise.
(C) The angular momentum of the disc about B is clockwise
(D) The angular momentum of the disc about A is equal to that about B.

MATCH THE COLUMN TYPE

Following questions contain statements given in two columns, which have to be matched. The statements in ***Column-I*** *are labelled as A, B, C and D while the statements in* ***Column-II*** *are labelled as (P), (Q), (R) and (S). Any given statement in* ***Column-I*** *can have correct matching with* ***ONE OR MORE*** *statement(s) in* ***Column-II****.*

Q.5 A rigid cylinder is kept on a smooth horizontal surface as shown. If **Column-I** indicates velocities of various points (3-centre of cylinder, 2- top point, 4-bottom point, 1- on the level of 3 at the rim) on it shown, choose correct state of motion from **Column-II**.



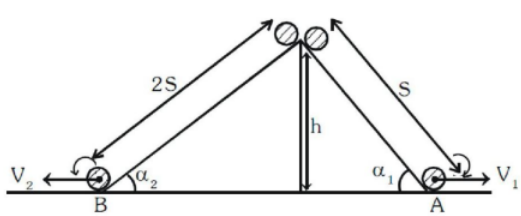
Column-I	Column-II
(A) $\vec{v}_1 = \hat{i}+\hat{j}, \vec{v}_2 = 2\hat{i}$	(P) Pure rotation about centre
(B) $\vec{v}_1 = \hat{i}+\hat{j}, \vec{v}_3 = -\hat{i}$	(Q) Rolling without slipping to left
(C) $\vec{v}_2 = \hat{i}, \vec{v}_3 = 0$	(R) Rolling without slipping to right
(D) $\vec{v}_4 = 0, \vec{v}_1 = -\hat{i}-\hat{j}$	(S) Not possible

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q.6 A hollow cylinder is rolling down on an inclined plane which is inclined at an angle m/sof 30° to the horizontal. Find the speed after travelling distance of 10 metre ?
(take g = 9.8 m/s^2)

Q.7 Two uniform similar discs roll down on two inclined planes of length S and 2S respectively as shown in the figure. Find the ratio of velocities of two discs at the point A and B of the inclined planes ?



SUBJECTIVE TYPE

Q.8 A disks rotates about a fixed axis. Its angular velocity ω varies with time according to equation $\omega = at + b$. At the instant $t = 0$ its angular velocity is 1.0 rad/s and angular position is 2 rad and at the instant $t = 2$ s, angular velocity is 5.0 rad/s. Determine angular position θ and angular acceleration α at $t = 4$ s.

Q.9 A rigid body rotate about a fixed axis with variable angular speed $\omega = A - Bt$ where A and B are constant. Find the angle through which it rotate before it comes to rest.

Q.10 The moment of inertia of a ring and a disc of same mass about their diameters are same. What will be the ratio of their radii ?

Q.11 Two bodies of mass 1Kg and 2Kg are attached to the ends of a 2 metre long weight less rod. This system is rotating about an axis passing through middle point of rod. Calculate M.I. of system.

Q.12 About which axis would a uniform cube have its minimum rotational inertia (moment of inertia) ?

Q.13 Three mass m_1, m_2 and m_3 are located at the vertices of an equilateral triangle of length a. What is moment of inertia of the system about an axis along the altitude of the triangle passing through m_1 ?

Q.14 The density of rod AB continiously increases from A to B. Is it easier to set it in rotation by clamping it at A and applying a perpendicular force at B or by clamping it at B and applying the force at A. Explain your answer.

Q.15 A wheel of moment of inertia 10 kg-m^2 is rotating at 10 rotations per minute. Find the work done in increasing its angular speed to 5 times of its initial value. (take $\pi^2 = 10$)

Q.16 A wheel is rotating about a fixed axis. Find the moment of inertia of the wheel about the axis of rotation, when its angular speed is 30 radian/sec and its kinetic energy is 360 joule ?

Q.17 A uniform circular disc of mass 200g and radius 4·0cm is rotated about one of its diameter at an angular speed of 10 rad/sec. Find the kinetic energy of the disc & its angular momentum about the axis of rotation ?

Q.18 A rotating platform of moment of inertia 100 kg–m^2 completes one rotations in 10 seconds. A person of mass 50 kg. is standing at the centre of platform. If the person moves at a distance of 2m. from the centre along the radius then find the angular velocity of the platform.

Q.19 Two disc have moments of inertia I_1 and I_2 about their respective axis (normal to the disc and passing the centre) and rotating with angular speeds ω_1 and ω_2 are brought into contact face to face with their axis of rotation coincident and directon of rotation is same then find the angular speed of the two disc system.

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q.1 Two loops P and Q are made from a uniform wire. The radii of P and Q are r_1 and r_2 respectively, and their moments of inertia are I_1 and I_2 respectively. If $\frac{I_2}{I_1} = 4$ then $\frac{r_2}{r_1}$ equals-

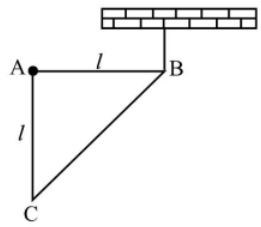
(A) $4^{2/3}$ (B) $4^{1/3}$ (C) $4^{-2/3}$ (D) $4^{-1/3}$

Q.2 The ratio of the radii of gyration of a circular disc about a tangential axis in the plane of the disc and of a circular ring of the same radius about a tangential axis in the plane of the ring is :-

(A) 2 : 1 (B) $\sqrt{5} : \sqrt{6}$

(C) 2 : 3 (D) 1 : $\sqrt{2}$

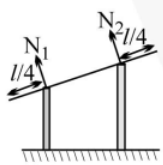
Q.3 A right triangular plate ABC of mass m is free to rotate in the vertical plane about a fixed horizontal axis through A. It is supported by a string such that the side AB is horizontal. The reaction at the support A in equilibrium is:



(A) $\frac{mg}{3}$ (B) $\frac{2mg}{3}$

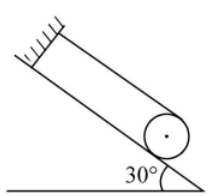
(C) $\frac{mg}{2}$ (D) mg

Q.4 A uniform rod of length l is placed symmetrically on two walls as shown in figure. The rod is in equilibrium. If N_1 and N_2 are the normal forces exerted by the walls on the rod then :-



(A) $N_1 > N_2$
(B) $N_1 < N_2$
(C) $N_1 = N_2$
(D) N_1 and N_2 would be in the vertical directions

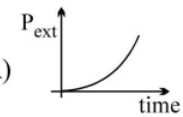
Q.5 A thin hoop of weight 500 N and radius 1 m rests on a rough inclined plane as shown in the figure. The minimum coefficient of friction needed for this configuration to be in equilibrium is:

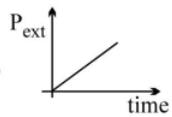


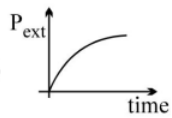
(A) $\frac{1}{3\sqrt{3}}$ (B) $\frac{1}{\sqrt{3}}$

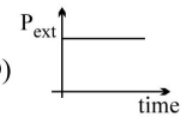
(C) $\frac{1}{2}$ (D) $\frac{1}{2\sqrt{3}}$

Q.6 A rod is hinged at its centre and rotated by applying a constant torque starting from rest. The power developed by the external torque as a function of time is :

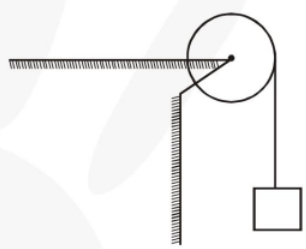
(A) 

(B) 

(C) 

(D) 

Q.7 Figure shows a uniform disk, with mass M = 2.4 kg and radius R = 20 cm, mounted on a fixed horizontal axle. A block of mass m = 1.2 kg hangs from a massless cord that is wrapped around the rim of the disk. The tension in cord is



(A) 12 N (B) 20 N

(C) 24 N (D) 6 N

Q.8 A particle moves in a circular path with decreasing speed. Choose the correct Statement :

(A) Angular momentum remains constant

(B) Acceleration ($\vec{a}$) is towards the centre

(C) Particle moves in a spiral path with decreasing radius

(D) The direction of angular momentum remains constant

Q.9 A particle of mass 2 kg located at the position $(\hat{i}+\hat{j})$ m has a velocity $2(\hat{i}-\hat{j}+\hat{k})$ m/s. Its angular momentum about z-axis in kg-m^2/s is:

(A) zero (B) +8 (C) 12 (D) –8

Q.10 Two bodies have their moments of inertia I and 2I respectively about their axis of rotation. If their kinetic energies of rotation are equal, their angular momenta will be in the ratio-

(A) 1 : 2 (B) $\sqrt{2}:1$

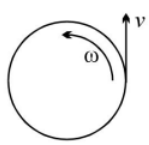
(C) $1:\sqrt{2}$ (D) 2 : 1

Q.11 A particle of mass m is projected with a velocity v making an angle of 45° with the horizontal. The magnitude of the angular momentum of the projectile about the point of projection when the particle is at its maximum height H is :-

(A) zero (B) $\frac{mv^3}{(4\sqrt{2}g)}$

(C) $\frac{mv^3}{\sqrt{2}g}$ (D) $m\sqrt{2gH^3}$

Q.12 A child with mass *m* is standing at the edge of a disc with moment of inertia I, radius R and initial angular velocity ω. See figure given below. The child jumps off the edge of the disc with tangential velocity *v* with respect to the ground. The new angular velocity of the disc is



(A) $\sqrt{\frac{I\omega^2 - mv^2}{I}}$

(B) $\sqrt{\frac{(I+mR^2)\omega^2 - mv^2}{I}}$

(C) $\frac{I\omega - mvR}{I}$

(D) $\frac{(I+mR^2)\omega - mvR}{I}$

Q.13 An ant is sitting at the edge of a rotating disc. If the ant reaches the other end, after moving along the diameter, the angular velocity of the disc will :-

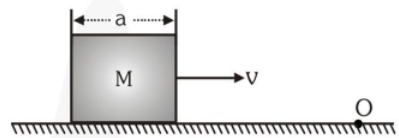
(A) remain constant

(B) first decreases and then increases

(C) first increases and then decreases

(D) increases continuously

Q.14 A cubical block of side 'a' moving with velocity v on a horizontal smooth plane as shown. It hits a ridge at point O. The angular speed of the block after it hits O is :-



(A) $\frac{3v}{4a}$ (B) $\frac{3v}{2a}$

(C) $\frac{\sqrt{3}}{\sqrt{2}a}$ (D) zero

Q.15 A smooth sphere A is moving on a frictionless horizontal plane with angular velocity ω and centre of mass velocity v. It collides elastically and head on with an identical sphere B at rest. Neglect friction everywhere. After the collision their angular speed are ω_A and ω_B respectively. Then :-

(A) $\omega_A < \omega_B$ (B) $\omega_A = \omega_B$

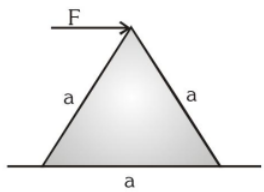
(C) $\omega_A = \omega$ (D) $\omega_B = \omega$

Q.16 Two particles each of mass M are connected by a massless rod of length *l*. The rod is lying on the smooth surface. If one of the particle is given an impulse Mv as shown in the figure then angular velocity of the rod would be

(A) v/*l* (B) 2v/*l*

(C) v/2*l* (D) None

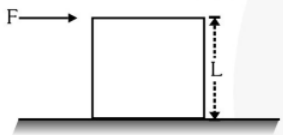
Q.17 An equilateral prism of mass m rests on a rough horizontal surface with coefficient of friction μ. A horizontal force F is applied on the prism as shown in the figure. If the coefficient of friction is sufficiently high so that the prism does not slide before toppling, then the minimum force required to topple the prism is-



(A) $\frac{mg}{\sqrt{3}}$ (B) $\frac{mg}{4}$

(C) $\frac{\mu mg}{\sqrt{3}}$ (D) $\frac{\mu mg}{4}$

Q.18 A cubical block of side L rests on a rough horizontal surface with coefficient of friction μ. A horizontal force F is applied on the block as shown. If the coefficient of friction is sufficiently high, so that the block does not slide before toppling, the minimum force required to topple the block is :-



(A) infinitesimal (B) $\frac{mg}{4}$

(C) $\frac{mg}{2}$ (D) mg (1 – μ)

Q.19 A solid sphere with a velocity (of centre of mass) v and angular velocity ω is gently placed on a rough horizontal surface. The frictional force on the sphere

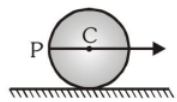
(A) must be forward (in direction of v)

(B) must be backward (opposite to v)

(C) cannot be zero

(D) none of the above

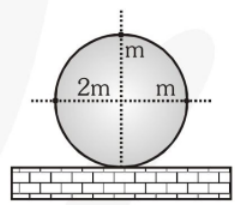
Q.20 A disc of radius R is pure rolling on a flat horizontal surface, with a constant angular velocity. The angle between the velocity and acceleration vectors of point P is



(A) Zero (B) 45°

(C) 135° (D) $\tan^{-1}(1/2)$

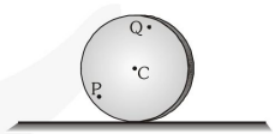
Q.21 A ring of mass m and radius R has three particles attached to the ring as shown in the figure. The centre of the ring has a speed v_0. The kinetic energy of the system is : (slipping is absent)



(A) $6\,mv_0^2$ (B) $12\,mv_0^2$

(C) $4\,mv_0^2$ (D) $8\,mv_0^2$

Q.22 A disc is rolling without slipping on a horizontal surface. C is its centre & Q and P are two points equidistant from C. Let v_P, v_Q and v_C be the magnitude of velocities of points P, Q & C respectively, then -

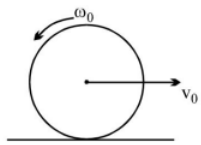


(A) $v_Q > v_C > v_P$ (B) $v_Q < v_C < v_P$

(C) $v_Q = v_P$, $v_C = \frac{1}{2}v_P$ (D) $v_Q < v_C > v_P$

Q.23 A uniform circular disc placed on a rough horizontal surface has initially a velocity v_0 and an angular velocity ω_0 as shown in the figure. The disc comes to rest after moving some distance in the direction of motion.

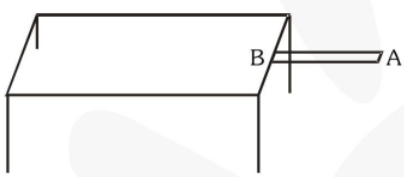
Then $\frac{v_0}{r\omega_0}$ is -



(A) $\frac{1}{2}$ (B) 1

(C) $\frac{3}{2}$ (D) 2

Q.24 A uniform thin stick of length ℓ and mass m is held horizontally with its end B hinged at a point B on the edge of a table. Point A is suddenly released. The acceleration of the centre of mass of the stick at the time of release, is :-



(A) $\frac{3}{4}g$ (B) $\frac{3}{7}g$

(C) $\frac{2}{7}r\ g$ (D) $\frac{1}{7}\ g$

Q.25 A spherical shell and a solid cylinder of same radius rolls down an inclined plane. The ratio of their accelerations will be:-

(A) 15:14 (B) 9:10

(C) 2:3 (D) 3:5

Q.26 A ring takes time t_1 and t_2 for sliding down and rolling down an inclined plane of length L respectively for reaching the bottom. The ratio of t_1 and t_2 is :-

(A) $\sqrt{2}$: 1 (B) 1 : $\sqrt{2}$

(C) 1 : 2 (D) 2 : 1

Q.27 Calculate the ratio of the times taken by a uniform solid sphere and a disc of the same mass and the same diameter to roll down through the same distance from rest on a smooth inclined plane.

(A) 15 : 14 (B) $\sqrt{15}:\sqrt{14}$

(C) $15^2 : 14^2$ (D) 1 : 1

Q.28 A body of mass m slides down an incline and reaches the bottom with a velocity v. If the same mass were in the form of a ring which rolls down this incline, the velocity of the ring at the bottom would have been

(A) v (B) $v\sqrt{2}$

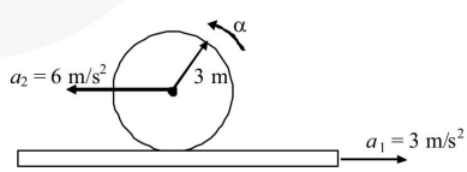
(C) $\frac{v}{\sqrt{2}}$ (D) $\sqrt{\frac{2}{5}}\times v$

Q.29 A solid cylinder of mass M and radius R rolls without slipping down an inclined plane of length L and height h. What is the speed of its centre of mass when the cylinder reaches its bottom-

(A) $\sqrt{2gh}$ (B) $\sqrt{\frac{3}{4}gh}$

(C) $\sqrt{\frac{4}{3}gh}$ (D) $\sqrt{4gh}$

Q.30 In the following figure, a sphere of radius 3 m rolls on a plank. The accelerations of the sphere and the plank are indicated. The value of α is -



(A) 3 rad/s^2

(B) 6 rad/s^2

(C) 3 rad/s^2 (opposite to the direction shown in figure)

(D) 1 rad/s^2

Q.31 The moment of inertia of a solid cylinder about its axis is given by $(1/2)MR^2$. If this cylinder rolls without slipping, the ratio of its rotational kinetic energy to its translational kinetic energy is -

(A) 1 : 1 (B) 2 : 2 (C) 1 : 2 (D) 1 : 3

Q.32 A disc rolls down a plane of length L and inclined at angle θ, without slipping. Its velocity on reaching the bottom will be :-

(A) $\sqrt{\frac{4gL\sin\theta}{3}}$ (B) $\sqrt{\frac{2gL\sin\theta}{3}}$

(C) $\sqrt{\frac{10gL\sin\theta}{7}}$ (D) $\sqrt{4gL\sin\theta}$

Q.33 If rotational kinetic energy is 50% of total kinetic energy then the body will be :–

(A) ring (B) cylinder

(C) hollow sphere (D) solid sphere

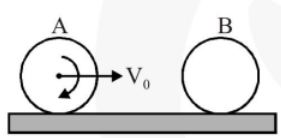
Q.34 A hollow smooth uniform sphere A of mass 'm' rolls without sliding on a smooth horizontal surface. It collides head on elastically with another stationary smooth solid sphere B of the same mass m and same radius. The ratio of kinetic energy of 'B' to that of 'A' just after the collision is:

(A) 1 : 1

(B) 2 : 3

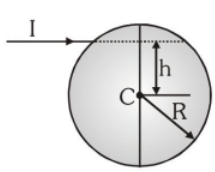
(C) 3 : 2

(D) None



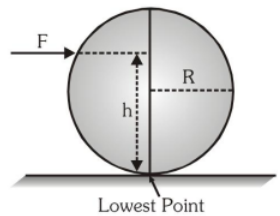
Q.35 A solid sphere is placed on a horizontal surface. A horizontal impulse I is applied at a distance h above the central line as shown in the figure. Soon after giving the impulse the sphere starts rolling.

The ratio h/R would be-



(A) $\frac{1}{2}$ (B) $\frac{2}{5}$ (C) $\frac{1}{4}$ (D) $\frac{1}{5}$

Q.36 A solid sphere of radius R is placed on smooth horizontal surface. A horizontal force 'F' is applied at height 'h' from the lowest point. For the maximum acceleration of centre of mass, which is correct-



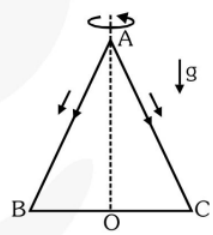
(A) h = R

(B) h = 2R

(C) h = 0

(D) No relation between h and R

Q.37 An equilateral triangle ABC formed from a uniform wire has two small identical beads initially located at A. The triangle is set rotating about the vertical axis AO. Then the beads are released from rest simultaneously and allowed to slide down, one along AB and other along AC as shown. Neglecting frictional effects, the quantities that are conserved as the beads slide down are :



(A) angular velocity and total energy (kinetic and potential)

(B) total angular momentum and total energy

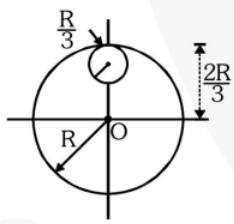
(C) angular velocity and moment of inertia about the axis of rotation

(D) total angular momentum and moment of inertia about the axis of rotation

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

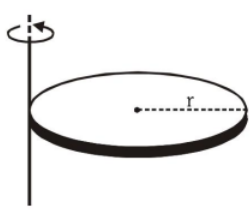
Q.1 From a circular disc of radius R and mass 9M, a small disc of radius $\frac{R}{3}$ is removed from the disc. The moment of inertia of the remaining disc about an axis perpendicular to the plane of the disc and passing through O is :-



(A) $4MR^2$ (B) $\frac{40}{9}MR^2$

(C) $10MR^2$ (D) $\frac{37}{9}MR^2$

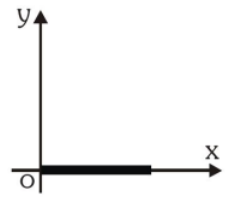
Q.2 A solid sphere of radius R has moment of inertia I about its geometrical axis. If it is melted into a disc of radius r and thickness t. If it's moment of inertia about the tangential axis (which is perpendicular to plane of the disc) is also equal to I, then the value of r is equal to :-



(A) $\frac{2}{\sqrt{15}}R$ (B) $\frac{2}{\sqrt{5}}R$

(C) $\frac{3}{\sqrt{15}}R$ (D) $\frac{\sqrt{3}}{\sqrt{15}}R$

Q.3 The figure shows a uniform rod lying along the x-axis. The locus of all the points lying on the xy-plane, about which the moment of inertia of the rod is same as that about O is



(A) an ellipse

(B) a circle

(C) a parabola

(D) a straight line

Q.4 A heavy seesaw (i.e., not massless) is out of balance. A light girl sits on the end that is tilted downward, and a heavy body sits on the other end so that the seesaw now balances. If they both move forward so that they are one-half their original distance from the pivot point (the fulcrum) what will happen to the seesaw ?

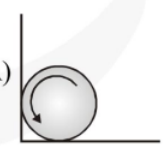
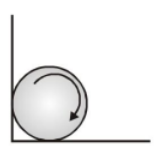
(A) The side the body is sitting on will tilt downward

(B) The side the girl is sitting on will once again tilt downward

(C) Nothing ; the seesaw will still be balanced

(D) It is impossible to say without knowing the masses and the distances

Q.5 A sphere is placed rotating with its centre initially at rest in a corner

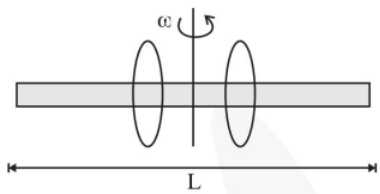
(A)  (B) 

as shown in figure (A) & (B). Coefficient of friction between all surfaces and the sphere is $\frac{1}{3}$. Find the ratio of the frictional force $\frac{f_a}{f_b}$ by ground in situations (A) & (B)

(A) 1 (B) 9/10

(C) 10/9 (D) None

Q.6 A smooth uniform rod of length L and mass M has two identical beads (1 and 2) of negligible size, each of mass m, which can slide freely along the rod. Initially the two beads are at the centre of the rod and the system is rotating with angular velocity ω_0 about an axis perpendicular to the rod and is passing through its mid-point. There are no external forces when the beads reach the ends of the rod, the angular velocity of the system is



(A) $\frac{M\omega_0}{M+6m}$ (B) $\frac{M\omega_0}{m}$

(C) $\frac{M\omega_0}{M+12m}$ (D) ω_0

Q.7 The torque $\vec{\tau}$ on a body about a given point is found to be equal to $\vec{A}\times\vec{L}$ where $\vec{A}$ is a constant vector and $\vec{L}$ is the angular momentum of the body about that point. From this it follows that :

(A) $d\vec{L}/dt$ is perpendicular to $\vec{L}$ at all instants of time

(B) the components of $\vec{L}$ in the direction of $\vec{A}$ does not change with time

(C) the magnitude of $\vec{L}$ does not change with time

(D) $\vec{L}$ does not change with time

Q.8 A block of mass m moves on a horizontal rough surface with initial velocity v. The height of the centre of mass of the block is h from the surface. Consider a point A on the surface.

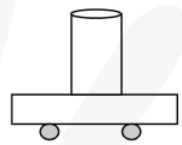
(A) angular momentum about A is mvh initially

(B) the velocity of the block decreases at time passes.

(C) torque of the forces acting on block is zero about A

(D) angular mometum is not conserved about A.

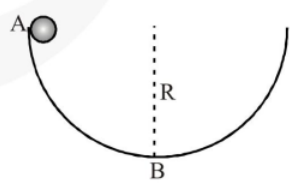
Q.9 A uniform 2 kg cylinder rests on a laboratory cart as shown. The coefficient of static friction between the cylinder and the cart is 0.5. If the cylinder is 4 cm in diameter and 10 cm in height, which of the following is closest to the maximum acceleration of the cart such that cylinder neither slips nor tips over?



(A) 2 m/s^2 (B) 4 m/s^2

(C) 5 m/s^2 (D) 6 m/s^{27}

Q.10 A small sphere A of mass m and radius r rolls without slipping inside a large fixed hemispherical bowl of radius R (>> r) as shown in figure. If the sphere starts from rest at the top point of the hemisphere find the normal force exerted by the small sphere on the hemisphere when it is at the bottom B of the hemisphere.



(A) $\frac{10}{7}$mg (B) $\frac{17}{7}$mg

(C) $\frac{5}{7}$ mg (D) $\frac{7}{5}$mg

Q.11 If a cylinder is rolling down the long incline with sliding

(A) after some time it may start pure rolling

(B) after some time it will start pure rolling

(C) it may be possible that it will never start pure rolling

(D) None of these

Q.12 A hollow sphere of radius R and mass m is fully filled with non viscous liquid of mass m. It is rolled down a horizontal plane such that its centre of mass moves with a velocity v. If it purely rolls.

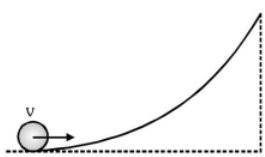
(A) Kinetic energy of the sphere is $\frac{5}{6}mv^2$

(B) Kinetic energy of the sphere is $\frac{4}{5}mv^2$

(C) Angular momentum of the sphere about a fixed point on ground is $\frac{8}{3}mvR$

(D) Angular momentum of the sphere about a fixed point on ground is $\frac{14}{5}mvR$

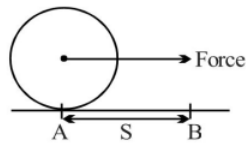
Q.13 A small object of uniform density rolls up a curved surface with an initial velocity v. It reaches up to a maximum height of $\frac{3v^2}{4g}$ with respect to the initial position. The object is :-



(A) ring (B) solid sphere

(C) hollow sphere (D) disc

Q.14 A disc of circumference s is at rest at a point A on a horizontal surface when a constant horizontal force begins to act on its centre. Between A and B there is sufficient friction to prevent slipping and the surface is smooth to the right of B. The disc moves from A to B in time T. To the right of B,



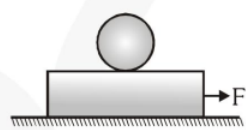
(A) the angular acceleration of the disc will disappear, linear acceleration will remain unchanged

(B) linear acceleration of the disc will increase

(C) the disc will make one rotation in time T/2

(D) the disc will cover a distance greater than s in further time T.

Q.15 A plank with a uniform sphere placed on it, rests on a smooth horizontal plane. Plank is pulled to right by a constant force F. If the sphere does not slip over the plank.



(A) Acceleration of centre of sphere is less than that of the plank.

(B) Acceleration of centre of sphere is greater than the plank because friction acts rightward on the sphere.

(C) Acceleration of the centre of sphere may be towards left.

(D) Acceleration of the centre of sphere relative to plank may be greater than that of the plank relative to floor.

Q.16 A ring rolls without slipping on the ground. Its centre C moves with a constant speed u. P is any point on the ring. The speed of P with respect to the ground is v.

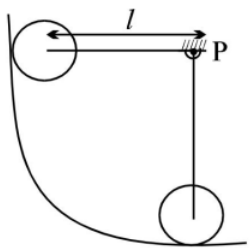
(A) $0 \le v \le 2u$

(B) $v = u$, if CP is horizontal.

(C) $v = u$, if CP makes an angle of 30° with the horizontal and P is below the horizontal level of C.

(D) $v = \sqrt{2}u$, if CP is horizontal.

Q.17 A sphere of mass M and radius R is attached by a light rod of length ℓ to a point P. The sphere rolls without slipping on a circular track as shown. It is released from the horizontal position. The angular momentum of the system about P when the rod becomes vertical is :



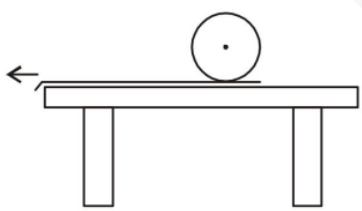
(A) $M\sqrt{\frac{10}{7}gl}\,[l+R]$

(B) $M\sqrt{\frac{10}{7}gl}\left[l+\frac{2}{5}R\right]$

(C) $M\sqrt{\frac{10}{7}gl}\left[l+\frac{7}{5}R\right]$

(D) $M\sqrt{\frac{10}{7}gl}\left[1-\frac{2}{5}R\right]$

Q.18 A thin table cloth covers a horizontal table and a uniform body of round shape lies on top of it. The table cloth is pulled from under the body, and friction causes the body to slide and rotate. What is the body's final motion on the table? (Assume that the table is so large that the body does not fall off it.)



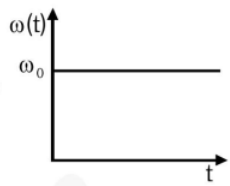
(A) Body will finally roll towards left

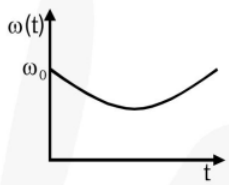
(B) Body will finally roll towards right

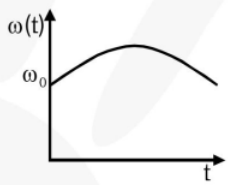
(C) Body will finally come to rest

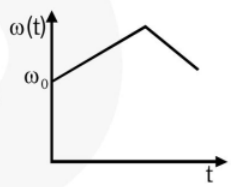
(D) Any of the above is possible depending on shape of body

Q.19 A circular platform is free to rotate in a horizontal plane about a vertical axis passing through its centre. A tortoise is sitting at the edge of the platform. Now the platform is given an angular velocity ω_0. When the tortoise move along a chord of the platform with a constant velocity (with respect to the platform). The angular velocity of the platform $\omega(t)$ will vary with time t as :-

(A)


(B)


(C)


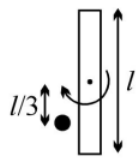
(D)


Q.20 A uniform rod AB of mass m and length l is at rest on a smooth horizontal surface. An impulse J is applied to the end B, perpendicular to the rod in the horizontal direction. Speed of particle P at a distance $\frac{l}{6}$ from the centre towards A of the rod after time $t = \frac{\pi m l}{12J}$ is-

(A) $2\frac{J}{m}$ (B) $\frac{J}{\sqrt{2}m}$

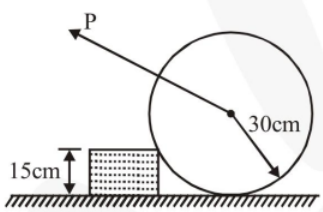
(C) $\frac{J}{m}$ (D) $\sqrt{2}\frac{J}{m}$

Q.21 A uniform rod of length l and mass M rotating about a fixed vertical axis on a smooth horizontal table. It elastically strikes a particle placed at a distance $l/3$ from its axis and stops. Mass of the particle is -



(A) 3M (B) $\frac{3M}{4}$ (C) $\frac{3M}{2}$ (D) $\frac{4M}{3}$

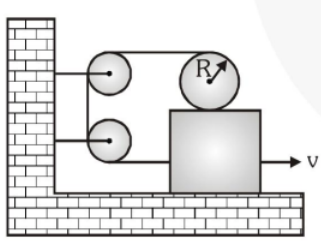
Q.22 In the given figure a uniform wheel of radius 30cm rests against a rigid rectangular block 15cm high. The wheel weighs 1000 N. The minimum pull P through the center which will turn the wheel over the block is :-



(A) $500\sqrt{3}$ N (B) $1000\sqrt{3}$ N

(C) 1000 N (D) $400\sqrt{3}$ N

Q.23 In the figure shown, the plank is being pulled to the right with a constant speed v. If the cylinder does not slip then -



(A) the speed of the centre of mass of the cylinder is 2v

(B) the speed of the centre of mass of the cylinder is zero

(C) the angular velocity of the cylinder is v/R

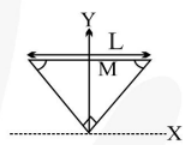
(D) the angular velocity of the cylinder is zero

Paragraph Type

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 24 to 37

The figure shows an isosceles triangular plate of mass M and base L. The angle at the apex is 90°. The apex lies at the origin and the base is parallel to X–axis



Q.24 The moment of inertia of the plate about the z-axis is :-

(A) $\frac{ML^2}{12}$ (B) $\frac{ML^2}{24}$

(C) $\frac{ML^2}{6}$ (D) none of these

Q.25 The moment of inertia of the plate about the y-axis is :-

(A) $\frac{ML^2}{6}$ (B) $\frac{ML^2}{8}$

(C) $\frac{ML^2}{24}$ (D) none of these

Q.26 The moment of inertia of the plate about the x-axis is :-

(A) $\frac{ML^2}{8}$ (B) $\frac{ML^2}{32}$

(C) $\frac{ML^2}{24}$ (D) $\frac{ML^2}{6}$

Q.27 The moment of inertia of the plate about its base parallel to the x-axis is :-

(A) $\frac{ML^2}{18}$ (B) $\frac{ML^2}{36}$

(C) $\frac{ML^2}{24}$ (D) none of these

Paragraph for Question on 28 and 29

In the treatment of moments of inertia, introductory textbooks often present two theorems, generally called the parallel axis theorem and the perpendicular axis theorem. There is another theorem of this same genre, which is not usually included, but which is interesting and useful. It is

$$I_x + I_y + I_z = 2\sum_i m_i r_i^2$$

Here, I_x, I_y and I_z are the moments of inertia about three mutually perpendicular intersecting axes, m_i is the mass of the ith particle and r_i is the distance from the intersection. The proof is simple: Taking the three axes as coordinate axes, we have :

$$I_x + I_y + I_z = \sum_i m_i\left(y_i^2 + z_i^2\right) + \sum_i m_i\left(z_i^2 + x_i^2\right) + \sum_i m_i\left(x_i^2 + y_i^2\right)$$

$$= 2\sum_i m_i\left(x_i^2 + y_i^2 + z_i^2\right) = 2\sum_i m_i r_i^2$$

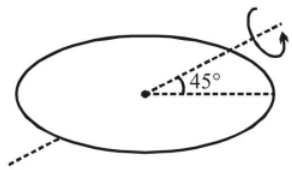
One important application is the calculation of the moment of inertia I_d of a uniform thin-walled spherical shell, of mass M and radius R, about a diameter. Taking the centre as the origin of coordinates, we have $I_x = I_y = I_z = I_d$, and $r_i = R$. The theorem gives $3I_d = 2\Sigma_i\, m_i R^2 = 2(\Sigma_i m_i)R^2 = 2MR^2$,where $I_d = 2MR^2/3$.

Q.28 Consider a solid cube of mass M and side L. What will be the value of $\Sigma m_i r_i^2$ for this body when the point of intersection of axes is the centre of the cube :

(A) $\frac{ML^2}{2}$ (B) $\frac{ML^2}{4}$

(C) $\frac{ML^2}{3}$ (D) $\frac{ML^2}{6}$

Q.29 Find the moment of inertia of ring of mass m and radius R about an axis passing through its centre and making an angle 45° with its plane :

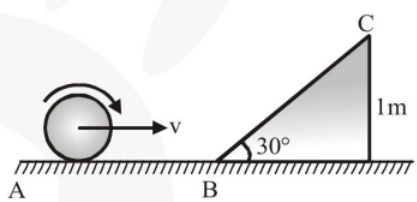


(A) $\frac{mR^2}{4}$ (B) $\frac{mR^2}{2}$

(C) $\frac{3}{4}mR^2$ (D) mR^2

Paragraph for Question No.30 and 31

A small sphere of mass 1 kg is rolling without slipping on a rough stationary base with linear speed $v = \sqrt{\frac{200}{7}}$ m/s. It leaves the inclined plane at point C.



Q.30 Find its linear speed at point C :-

(A) $\sqrt{\frac{100}{7}}$ m/s (B) $\sqrt{\frac{50}{7}}$ m/s

(C) $\sqrt{\frac{100}{35}}$ m/s (D) $\sqrt{\frac{200}{35}}$ m/s

Q.31 Find ratio of rotational and translational kinetic energy of the sphere when it strikes the ground after leaving from point C :-

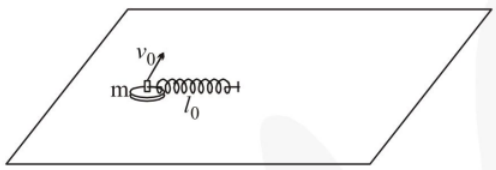
(A) $\frac{2}{5}$ (B) $\frac{2}{3}$

(C) $\frac{1}{6}$ (D) $\frac{1}{2}$

Paragraph for Question on 32 to 35

A spring having initial unstretched length ℓ_0 is lying on a smooth table. It's one end is fixed and the other one is fastened to a small particle of mass m. The particle is imparted an initial speed v_0 horizontally in a direction perpendicular to the spring. In the course of the motion in horizontal plane, the maximum elongation of the spring is $\Delta\ell = \ell_0/10$.

(Given : m = 0.1 kg, ℓ_0 = 1m, v_0 = 11 m/s).



Q.32 In the course of motion, which of the quantities relating to spring block system are conserved ?

(A) kinetic energy

(B) momentum

(C) angular momentum

(D) potential energy

Q.33 Which of the following is correct about initial situation and situation at maximum elogation ?

(A) The orientiation of spring in both positions should be perpendicular to each other.

(B) The velocity at maximum extension should be zero

(C) The velocity at maximum extension as well as at initial position should be perpendicular to spring.

(D) Acceeration should be zero at the maximum extension as well as at initial position.

Q.34 **Student-A :** at maximum extension $mv_1(\ell_0 + \Delta\ell) = mv_0\ell_0$.

Student-B : at maximum extension $k\Delta\ell = \dfrac{mv_1^2}{(\ell_0 + \Delta\ell)}$.

Student-C : $\dfrac{1}{2}mv_0^2 = \dfrac{1}{2}mv_1^2 + \dfrac{1}{2}k\Delta\ell^2$.

where v_1 is velocity at instant of maximum extension :

(A) Only Student-A and B are correct

(B) Only Student-A and C are correct

(C) Only Student-B and C are correct

(D) All are correct

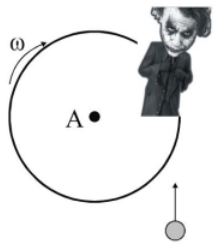
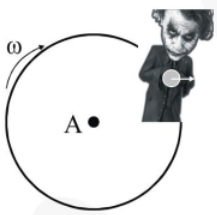
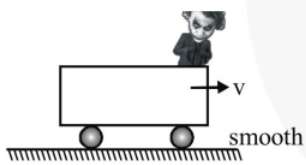
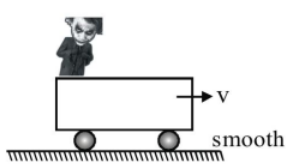
Q.35 The value of spring constant (in N/m) is :

(A) 100 (B) 210 (C) 420 (D) 105

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

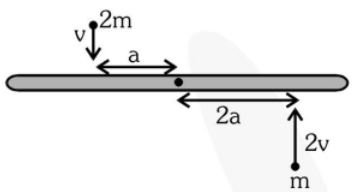
Q.36 Column-I depicts various situations where some sudden events are taking place. Column-II describes changes in various parameters of systems immediately after the events taking place in column-I. (Platform is hinged at A & free to rotate)

Column-I	Column-II
(A) Joker is standing on revolving platform and batman throws the ball and joker catches the ball while it was moving horizontally.  Joker, ball and platform is system.	(P) Linear momentum remains conserved.
(B) Joker throws the ball horizontally and perpendicular to his motion while standing on the revolving platform.  Joker, ball and platform is system.	(Q) Mechanical energy is conserved
(C) Joker jumps horizontally towards right from the cart which is moving at speed v on smooth horizontal floor.  Joker and cart is the system	(R) Mechanical energy increases.
(D) Joker drops himself vertically from the moving cart with no horizontal velocity relative to cart.  Joker and cart is the system	(S) Mechanical energy decreases. (T) v or ω changes

SUBJECTIVE TYPE

Q.37 If the moment of inertia of a disc about an axis tangentially and parallel to its surface be I, what will be the moment of inertia about the axis tangential but perpendicular to the surface.

Q.38 A uniform rod of mass 8m and length 6a is lying on a horizontal table. Two point masses m and 2m moving with speed 2v and v respectively strike the rod and stick to it as shown in figure then-

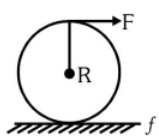


(a) Calculate the speed of centre of mass of rod after the collision.

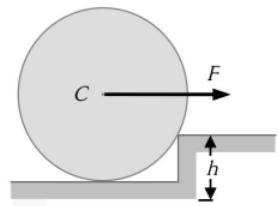
(b) Calculate angular velocity of the rod about an axis passing through its centre of mass.

(c) Kinetic energy of system after collision.

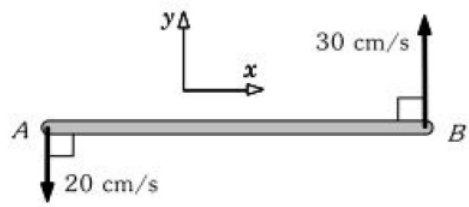
Q.39 A tangential force F acts at the top of a thin spherical shell of mass m and radius R. Find the acceleration of the shell if it rolls without slipping.



Q.40 A cylinder of radius R and weight W is to be raised against a step of height h by applying a horizontal force at its center as shown in the figure. Find the required minimum magnitude of this force. Assume sufficient friction between the cylinder and the corner of the step to prevent slipping. (given that R = 2h)



Q.41 A 100 cm rod is moving on a horizontal surface. At an instant, when it is parallel to the x-axis its ends A and B have velocities 30 cm/s and 20 cm/s as shown in the figure.



(a) Find its angular velocity and velocity of its center.

(b) Locate its instantaneous axis of rotation.

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
D	A	C	B	B	B	C	A	A	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	C	D	A	B	D	B	C	A	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
D	C	C	A	B	D	B	B	B	C
31	**32**	**33**							
D	**C**	**C**							

Ex-1A

1. (A,B,C) **2.** (A,C,D) **3.** (D) **4.** (A,B,C)

5. (A)-R, (B)-S, (C)-P, (D)-Q **6.** 7m/s **7.** $\frac{v_1}{v_2} = 1$

8. $\alpha = 2$ rad/s^2, $\theta = 22$ rad. **9.** $\theta = \frac{A^2}{2B}$ **10.** $\frac{R_1}{R_2} = \frac{1}{\sqrt{2}}$

11. 3 kg-m^2 **12.** Body diagonal **13.** $\frac{a^2}{4}(m_2 + m_3)$

14. See Explanation **15.** 133.3 J **16.** I = 0.8 kg-m^2

17. 4×10^{-3} J, 8×10^{-4} J-s **18.** $\frac{\pi}{15}$ rad / sec. **19.** $\omega = \frac{I_1\omega_1 + I_2\omega_2}{I_1 + I_2}$

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
B	B	B	C	D	B	D	D	D	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	D	C	A	C	A	A	C	D	B
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	A	A	A	B	B	D	C	C	A
31	**32**	**33**	**34**	**35**	**36**	**37**			
C	A	A	C	B	D	B			

Ex-2A

1. A	**2.** A	**3.** B	**4.** B	**5.** B
6. A	**7.** A,B,C	**8.** A,B,D	**9.** B	**10.** B
11. A,C	**12.** C	**13.** D	**14.** B,C,D	**15.** A
16. A,C,D	**17.** D	**18.** C	**19.** C	**20.** D
21. B	**22.** A	**23.** B, C	**24.** C	**25.** C
26. A	**27.** C	**28.** B	**29.** C	**30.** A
31. C	**32.** C	**33.** C	**34.** B	**35.** B

36. (A) ST (B) R (C) PRT (D) PQ

37. $I' = \frac{6}{5} I$ **38.** (a) $v_C = 0$, (b) $\omega = \frac{v}{5a}$ anticlockwise. (c) KE = $\frac{3mv^2}{5}$

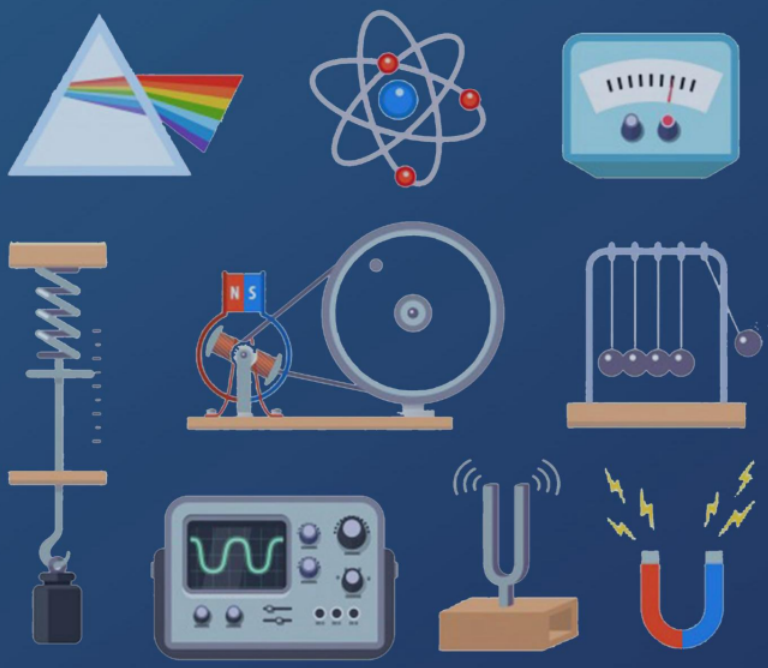
39. $\frac{6F}{5m}$ **40.** $F = \sqrt{3}W$

41. (a) $\omega = 0.5$ rad/s , $\overrightarrow{V_C} = -20\hat{j} + 0.5\hat{k} \times 50\hat{i} = 5.0\hat{j}$ cm/s

(b) 40cm from A.

PHYSICS

Semiconductors



SHEET

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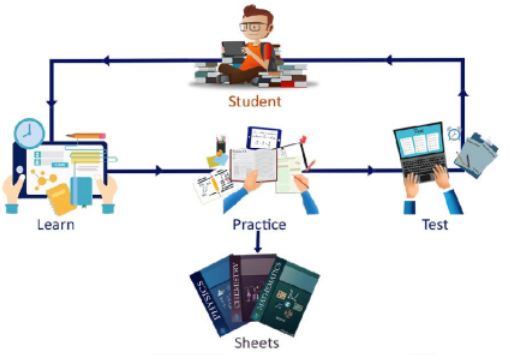
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-2
1	Introduction		1
2	Energy band gap	1,2,3	2
3	Intrinsic Semiconductor	4	3
4	Extrinsic Semiconductor	5,6	4,5
5	p-n junction	7,8,9,10	6-10
6	Rectifier	11,12	11,12
7	Special purpose diode	13,14	13,14
8	Transistor	15,16,17	15-19
9	Amplifier and switch	18,19,20,21	20-22
10	Logic gates	22,23,24	23-25

Exercise - 1 Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Energy band gap

Q1. In semiconductor the valence band at 0 K is-

(A) completely filled

(B) completely empty

(C) partially filled

(D) nothing can be said

Q2. The energy gap in a semiconductor is of the order of :-

(A) 1 eV (B) 5 eV

(C) 10 eV (D) 15 eV

Q3. Choose the only false statement from the following :

(A) the resistivity of a semiconductor increases with increase in temperature

(B) substances with energy gap of the order of 10eV are insulators

(C) in conductors the valence and conduction bands may over lap

(D) the conductivity of a semiconductor increases with increases in temperature

Intrinsic Semiconductor

Q4. The forbidden energy gap in Ge is :-

(A) 0.72 eV

(B) 0.072 eV

(C) 7.2 eV

(D) 0.0072 eV

Extrinsic Semiconductor

Q5. P type semi conductor is :-

(A) positively charged

(B) made by mixing of impurity of boron in germanium

(C) made by mixing of impurity of phosphorus in silicon.

(D) made by mixing of impurity of carbon in silicon

Q6. In sample of pure silicon 10^{13} atom/cm^3 is mixed of phosphorus. If all doner atoms are active then what will be resistivity at 20^0C if mobility of electron is 1200 cm^2/Volt sec:-

(A) 0.5209 ohm/cm

(B) 5.209 ohm/cm

(C) 52.09 ohm/cm

(D) 520.9 ohm/cm

p-n junction

Q7. The depletion region of a p-n junction contains :–

(A) electrons only

(B) electrons and holes both

(C) holes only

(D) neither electrons nor holes

Q8. When a p-n junction is reversed biased, then the current through the junction is mainly due to :-

(A) diffusion of charge

(B) nature of the material

(C) drift of the charges

(D) both drift and diffusion of the charges

Q9. The p-n junction is a :-

(A) ohmic resistance

(B) non ohmic resistance

(C) positive resistance

(D) nagative resistance

Q10. The minority current in a p-n junction is :-

(A) From the n-side to the p-side

(B) From the p-side to the n-side

(C) From the n-side to the p-side if the junction is forward-biased and in the opposite direction if it is reverse biased

(D) From the p-side to the n-side if the junction is forward-biased and in the opposite direction if it is reverse biased

Rectifier

Q11. A device whose one end is connected to -ve terminal and the other is connected to +ve terminal, if both ends are interchanged with supply then current is not flowing then device will be :-

(A) p-n junction (B) transistor

(C) zener diode (D) triode

Q12. When two semiconductor of p and n type are brought into contact, they form a p-n junction which acts like a :-

(A) rectifier (B) amplifier

(C) oscillator (D) conductor

Special purpose diode

Q13. Zener diode is used for :-

(A) rectification

(B) stabilisation

(C) amplification

(D) producing oscillations in an oscillator

Q14. The energy of radiation emitted by LED is:-

(A) Greater than the band gap of the semiconductor used.

(B) Always less than the band gap of the semiconductor used.

(C) Always equal to the band gap of the semiconductor used.

(D) Equal to or less than the band gap of the semiconductor used.

Transistor

Q15. In transistor symbols, the arrows shows the direction of :–

(A) current in the emitter

(B) electron current in the emitter

(C) holes current in the emitter

(D) electron current in the emitter

Q16. The region of trasistor in which extra impurity is doped to obtain a large number of majority carrier is called as :–

(A) emitter

(B) base

(C) collector

(D) any one of these depending upon the trasistor

Q17. In a transistor :–

(A) The emitter has the least concentration of impurity

(B) The collector has the least concentration of impurity

(C) The base has the least concentration of impurity

(D) All the three regions have equal concentration of impurity

Amplifier and switch

Q18. A common Emitter circuit is used as an amplifier, whose current gain is 50. If input resistance is 1kΩ and input voltage is 5 volt then output current will be :–

(A) 250 mA (B) 30 mA

(C) 50 mA (D) 100 mA

Q19. A transistor is used in the common emitter mode as an amplifier then :–

(A) The base emitter junction is forward baised.

(B) The base emitter junction is reverse baised.

(C) The input signal is connected in series with the voltage applied to bias the base emitter junction.

(D) The input signal is connected in series with the voltage applied to bias the base collector junction.

(A) A, B (B) A, D

(C) A, C (D) only C

Q20. In CB configuration of transistor ac current gain is $\frac{\Delta i_C}{\Delta i_E} = 0.98$ determine current gain of CE configuration :–

(A) 49 (B) 98

(C) 4.9 (D) 24.5

Q21. For a transistor amplifier power gain and voltage gain are 7.5 and 2.5 respectively. The value of the current gains will be :–

(A) 0.33 (B) 0.66

(C) 0.99 (D) 3

Logic gates

Q22. In Boolean algebra Y = A + B implies that

(A) Output Y exists when both input A and B exist

(B) Output Y exists when either input A exists or input B exists or both inputs A and B exist

(C) Output Y exists when either input A exists or input B exists but not when both inputs A and B exist.

(D) output Y exists when both inputs A and B exist but not when either input A or B exists.

Q23. The truth table given above is for which of the following gates :–

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

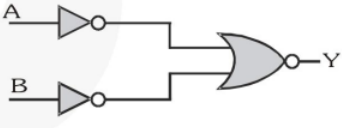
(A) NOR gate

(B) AND gate

(C) OR gate

(D) NAND gate

Q24. Which logic gate is represented by the following combination of logic gate :-



(A) OR

(B) NAND

(C) AND

(D) NOR

Q25. In the Boolean algebra, the following one which is not equal to A is-

(A) A.A

(B) A + A

(C) $\overline{A}.A$

(D) $\overline{\overline{A}+\overline{A}}$

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Directions for Assertion & Reason Questions

These questions Consist of two Statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

(A) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.

(B) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(C) If Assertion is True but the Reason is false.

(D) If both Assertion & Reason are false.

Q1. **Assertion :** If the temperature of a semiconductor is increased, its resistance decreases.

Reason : The energy gap between conduction band and valence band in case of semiconductor is small.

(A) A (B) B

(C) C (D) D

Q2. If a battery of 5V is connected across a plate of the semiconductor of area 2×10^{-4} m^2 and of thickness 1.2×10^{-3} m, then the current flowing through the plate is :-

(A) 0.32 mA (B) 0.64 mA

(C) 1.28 mA (D) 2.56 mA

Directions for Assertion & Reason Questions

These questions Consist of two Statements each, printed as Assertion and Reason. While answering these Questions you are required to choose any one of the following four responses.

(A) If both Assertion & Reason are True & the Reason is a correct explanation of the Assertion.

(B) If both Assertion & Reason are True but Reason is not a correct explanation of the Assertion.

(C) If Assertion is True but the Reason is false.

(D) If both Assertion & Reason are false.

Q3 **Assertion :** Germanium is preferred over silicon for making semiconductor devices.

Reason : Energy gap for Ge is more than that of Si.

(A) A (B) B

(C) C (D) D

Q4. If number of holes and free electrons in semiconductor are n_p and n_e respectively then :–

(A) $n_P > n_e$ in intrinsic semiconductor

(B) $n_P = n_e$ in extrinsic semiconductor

(C) $n_P = n_e$ in intrinsic semiconductor

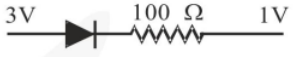
(D) $n_e > n_p$ in intrinsic semiconductor

Q5. For pure "Ge" semiconductor quantity of "e" and hole is 10^{19} e/m^3, if we doped donor impurity in it with density 10^{23} e/m^3 then quantity of hole (e/m^3) in semiconductor is:-

(A) 10^{15} (B) 10^{19}

(C) 10^{23} (D) 10^{27}

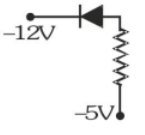
Q6. Assuming that the junction diode is ideal the current through the diode is :-

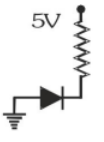


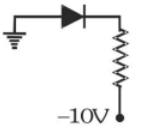
(A) 200 mA (B) 20 mA

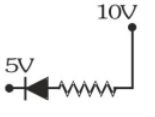
(C) 2 mA (D) zero

Q7. In given diagram which p-n junction is reverse biased

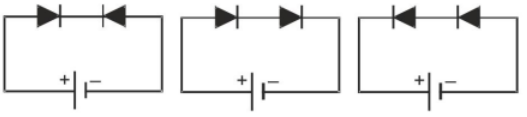
(A)


(B)


(C)


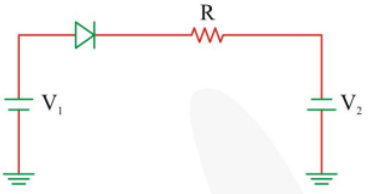
(D)


Q8. Two indentical P-N Jn. may be connected in series with a battery in three ways (fig below). the potential drops across the two P-N Jn. are equal in :–



(A) circuit 1 and 2 (B) circuit 2 and 3
(C) circuit 3 and 1 (D) circuit 1 only

Q9. If $V_1 > V_2$, r is resistance offered by diode in forward bias then current through the diode is :-



(A) 0 (B) $\frac{V_1 + V_2}{R + r}$

(C) $\frac{V_1 - V_2}{R + r}$ (D) None

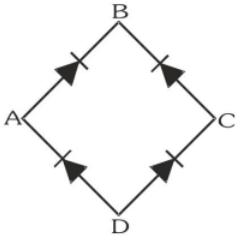
Q10. For a junction diode , the ratio of forward current (I_f) and reverse current is :

[I_e = electronic charge,
V = voltage applied across junction,
k = Boltzmann constant
T = temperature in kelvin]

(A) $e^{-V/kT}$ (B) $e^{V/kT}$

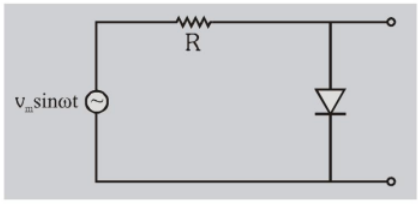
(C) $\left(e^{eV/kT} - 1\right)$ (D) $\left(e^{V/kT} - 1\right)$

Q11. In the figure, input is applied across A and C and output is taken across B and D, then the output is :



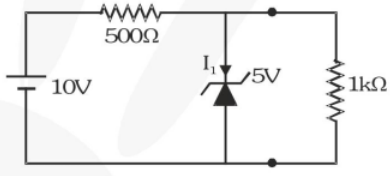
(A) zero
(B) same as input
(C) full wave rectified
(D) half wave rectified

Q12. The output across the diode in the given circuit in figure.



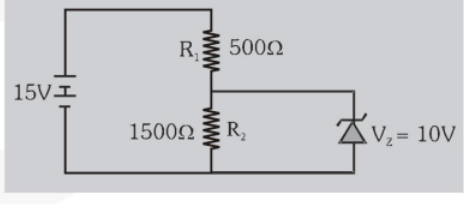
(A) Would be zero at all times.
(B) Would be like a half wave rectifier with positive cycles in output.
(C) Would be like a half wave rectifier with negative cycles in output.
(D) Would be like that of a full wave rectifier.

Q13. The current flowing through the zener diode in figure is :–



(A) 20 mA (B) 25 mA
(C) 15 mA (D) 5 mA

Q14. In the circuit given the current through the zener diode is :-



(A) 10 mA (B) 6.67 mA
(C) 5 mA (D) 3.33 mA

Q15. In an n-p-n transistor circuit, the collector current is 20 mA. If 90% of electron emitted reach the collector :–

(A) the emitter current will be 18 mA
(B) emitter current will be 22 mA
(C) base current will be 2 mA
(D) base current will be 1 mA

Q16. The current of transistor in common emitter mode is 49. The change in collector current and emitter current corresponding to the change in the base current by 5.0 μA, will be :–

(A) 245 μA, 250 μA (B) 240 μA, 235 μA
(C) 260 μA, 255 μA (D) none of these

Q17. For transistor current relation is :-

(A) $\alpha = \frac{\beta}{1-\beta}$ (B) $\beta = \frac{\alpha}{1-\alpha}$

(C) $\alpha = \frac{1+\beta}{\beta}$ (D) $\beta = \frac{1+\alpha}{\alpha}$

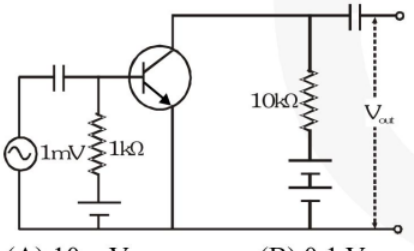
Q18. npn transistors are preferred to pnp transistors because they have

(A) low cost
(B) low dissipation energy
(C) capable of handling large power
(D) electrons have high mobility than holes and hence high mobility of energy.

Q19. In a common emitter amplifier, the phase difference between the input signal voltage and output voltage is :-

(A) $\frac{\pi}{2}$ (B) 0 (C) π (D) $\frac{\pi}{4}$

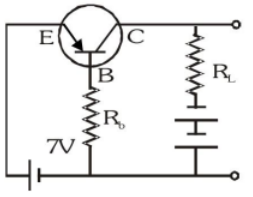
Q20. In the following common emitter configuration an 'npn' transistor with current gain β = 100 is used. The output voltage of amplifier will be :-



(A) 10 mV (B) 0.1 V
(C) 1.0 V (D) 10 V

Q21. In the given transistor circuit, the base current is 35 μA. The value of R_b is V_{BE} is assumed to negligible :-

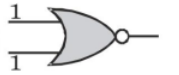
(A) 100 kΩ
(B) 300 kΩ
(C) 200 kΩ
(D) 400 kΩ

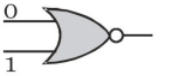


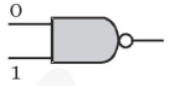
Q22. In a transistor amplifier β = 62, R_L = 5000 Ω and internal resistance of the transistor is 500 Ω. Its power amplification will be :

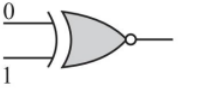
(A) 25580 (B) 33760
(C) 38440 (D) 55280

Q23. Which of the following gates will have an output of 1 :–

(a) 

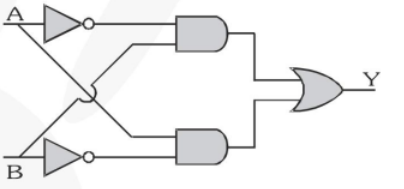
(b) 

(c) 

(d) 

(A) (a) and (b) (B) (b) and (c)
(C) (c) and (d) (D) (a) and (d)

Q24. Which of the following represents correctly the truth table of configuration of gates shown here



(A)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	1

(B)

A	B	Y
0	0	1
0	1	0
1	0	0
1	1	1

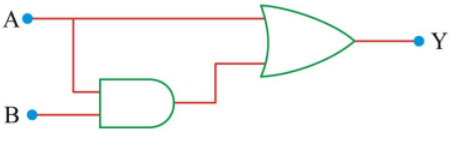
(C)

A	B	Y
0	0	0
0	1	1
1	0	1
1	1	0

(D)

A	B	Y
0	0	1
0	1	1
1	0	1
1	1	0

Q25. The output of the combination of the gates shown in the figure below is :-



(A) A + A. B (B) $A.(A+B)$
(C) $(A.B)+(\overline{A.B})$ (D) $(A+B)(\overline{A.B})$

Answer Key

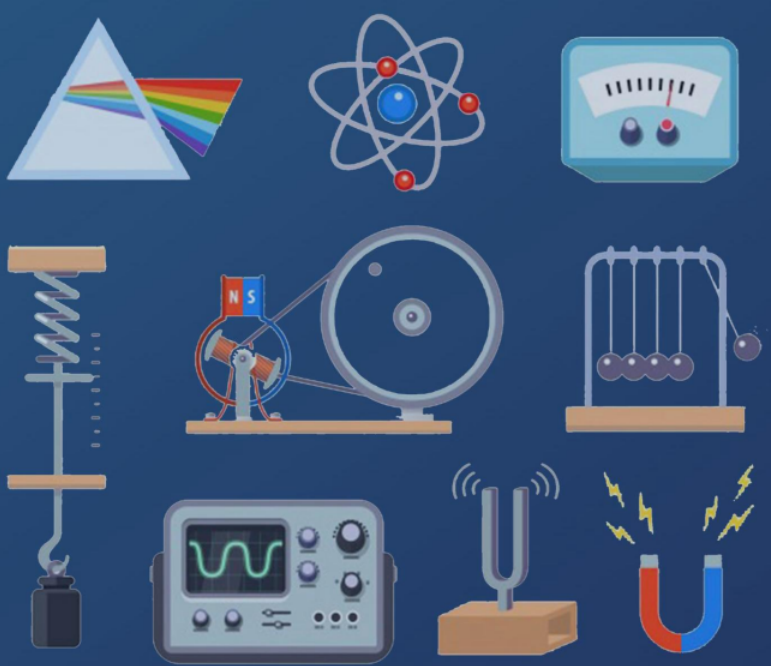
Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	A	A	A	B	D	D	A	B	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	A	B	D	A	A	C	A	C	A
21	**22**	**23**	**24**	**25**					
D	B	C	C	C					

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	C	D	C	A	B	B	B	B	C
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
C	C	D	D	D	A	B	D	C	C
21	**22**	**23**	**24**	**25**					
C	C	C	C	A					

-: Important Notes & Formulas :-

PHYSICS

Simple Harmonic Motion



SHEET

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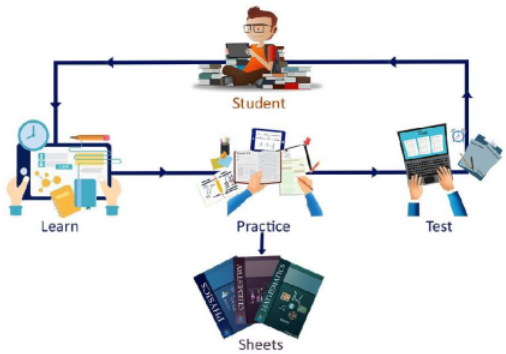
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Introduction to SHM	1-4	1,2		
2	Phasor Diagram	5	8,9	1	
3	Velocity and Acceleration Analysis	6	3,10,11	2-4	1-4
4	Understanding Graphs	7-10		5,6	16
5	Energy in SHM	11,12	4,5,12	7,8	5,6,17
6	Spring Block System	13-15	13,14	9,10	7,8,18
7	Variation in Parameters in SHM		7		9
8	Two Blocks SHM		6		
9	Simple Pendulum	16	15	11	
10	Physical Pendulum				
11	Miscelleneous Angular SHM			12	
12	Composition of SHM	17		13	10,11,14, 15
13	Damped SHM	18			
14	Forced Oscillations and Resonance				
15	After complete chapter			14,15	12,13,19

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Introduction to SHM

Q1. The equation of motion of a particle executing S.H.M. where letters have usual meaning is :

(A) $\frac{d^2x}{dt^2} = -\frac{k}{m}x$

(B) $\frac{d^2x}{dt^2} = +\omega^2 x$

(C) $\frac{d^2x}{dt^2} = -\omega^2 x^2$

(D) $\frac{d^2x}{dt^2} = -kmx$

Q2. The equation of a simple harmonic motion is $x = 0.34\cos(3000t + 0.74)$. Where x and t are in mm and sec. respectively.

The frequency of the motion is :

(A) 3000 (B) $3000/2\pi$

(C) $0.74/2\pi$ (D) $3000/\pi$

Q3. The equation of motion of a particle executing SHM is $\left(\frac{d^2x}{dt^2}\right) + kx = 0$. The time period of the particle will be :

(A) $2\pi/\sqrt{k}$ (B) $2\pi/k$

(C) $2\pi k$ (D) $2\pi\sqrt{k}$

Q4. The angular frequency of motion whose equation is $4\frac{d^2y}{dt^2} + 9y = 0$ is

(y = displacement and t = time)

(A) $\frac{9}{4}$ (B) $\frac{4}{9}$

(C) $\frac{3}{2}$ (D) $\frac{2}{3}$

Phasor Diagram

Q5. The phase of a particle in SHM on X axis at time t is $\pi/6$. The following inference is drawn from this:

(A) The particle is at $x = a/2$ and moving in + X-direction

(B) The particle is at $x = a/2$ and moving in – X-direction

(C) The particle is at $x = -a/2$ and moving in + X-direction

(D) The particle is at $x = -a/2$ and moving in – X-direction

Velocity and Acceleration Analysis

Q6. The displacement of a particle in S.H.M. is indicated by equation $y = 10\sin(20t + \pi/3)$ where y is in metres. The value of time period of vibration will be (in seconds) :

(A) $10/\pi$ (B) $\pi/10$

(C) $2\pi/10$ (D) $10/2\pi$

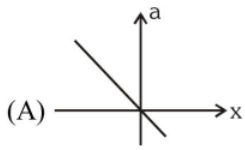
Understanding Graphs

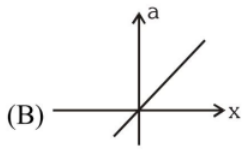
Q7. If the maximum velocity of a particle in SHM is v_0. then its velocity at half the amplitude from position of rest will be :

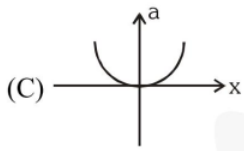
(A) $v_0/2$ (B) v_0

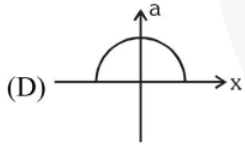
(C) $v_0\sqrt{3/2}$ (D) $v_0\sqrt{3}/2$

Q8. The variation of acceleration (a) and displacement (x) of the particle executing SHM is indicated by the following curve :

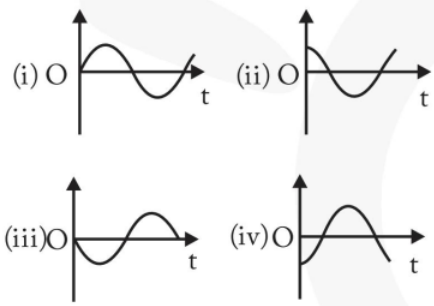
(A) 

(B) 

(C) 

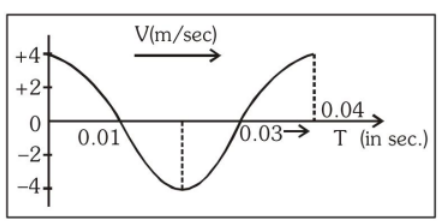
(D) 

Q9. The displacement of a particle in S.H.M. is $x = a\sin\omega t$. Which of the following graph between displacement and time is correct :



(A) (i) (B) (ii) (C) (iii) (D) (iv)

Q10. The velocity-time diagram of a harmonic oscillator is shown in the adjoining figure. The frequency of oscillation is :



(A) 25 Hz (B) 50 Hz
(C) 12.25 Hz (D) 33.3 Hz

Energy in SHM

Q11. The total energy of a harmonic oscillator of mass 2kg is 9 joules. If its potential energy at mean position is 5 joules, its K.E. at the mean position will be :

(A) 9 J (B) 14 J
(C) 4 J (D) 11 J

Q12. The value of total mechanical energy of a particle in S.H.M. is :

(A) Always constant

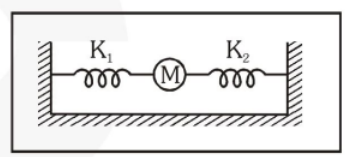
(B) Depend on time

(C) $\frac{1}{2}\,kA^2\cos^2(\omega t+\phi)$

(D) $\frac{1}{2}\,mA^2\cos^2(\omega t+\phi)$

Spring Block System

Q13. In the adjoining figure the frequency of oscillation for a mass m will be proportional to :



(A) K_1K_2 (B) $K_1 + K_2$
(C) $\sqrt{K_1+K_2}$ (D) $\sqrt{1/K_1+K_2}$

Q14. A horizontal spring is connected to a mass M. It executes simple harmonic motion. When the mass M passes through its mean position, an object of mass m is put on it and the two move together. The ratio of frequencies before and after will be-

(A) $\left(1+\frac{m}{M}\right)^{1/2}$ (B) $\left(1+\frac{m}{M}\right)$

(C) $\left(\frac{M}{M+m}\right)^{1/2}$ (D) $\left(\frac{M}{M+m}\right)$

Q15. A spring of force constant k is cut into two pieces such that one piece is double the length of the other. Then the long piece will have a force constant of :-

(A) $\frac{2}{3}k$ (B) $\frac{3}{2}k$

(C) 3k (D) 6k

Simple Pendulum

Q16. A bob is attached to a long, light string of length 1m. The string is deflected by 3° initially with respect to vertical. The value of θ at any time t after the bob released can be approximately written as (Use $g = \pi^2$)

(A) $3° \cos \pi t$

(B) $3° \sin \pi t$

(C) $3° \sin (\pi t + \frac{\pi}{6})$

(D) $3° \cos (\pi t + \frac{\pi}{6})$

Composition of SHM

Q17. The displacement of a particle varies with time according to the relation $y = a \sin \omega t + b \cos \omega t$.

(A) The motion is oscillatory but not S.H.M.

(B) The motion is S.H.M. with amplitude $a + b$.

(C) The motion is S.H.M. with amplitude $a^2 + b^2$.

(D) The motion is S.H.M. with amplitude $\sqrt{a^2 + b^2}$

Damped SHM

Q18. The amplitude of a damped oscillator becomes half in one minute. The amplitude after 3 minutes will be $\frac{1}{x}$ times of the original. Determine value of x.

(A) 4 (B) 8 (C) 16 (D) 3

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A necessary and sufficient condition for SHM is

(A) constant period.

(B) constant acceleration.

(C) proportionality between acceleration and displacement from equilibrium position.

(D) proportionality between the restoring force and displacement from equilibrium position.

Q2. The rotation of earth about its axis is :-

(A) periodic motion.

(B) simple harmonic motion.

(C) Oscillatory motion.

(D) Vibration

Q3. A particle is executing SHM between points $-X_m$ and X_m, as shown in figure-I. The velocity V(t) of the particle is partially graphed and shown in figure-II. Two points A and B corresponding to time t_1 and time t_2 respectively are marked on the V(t) curve.

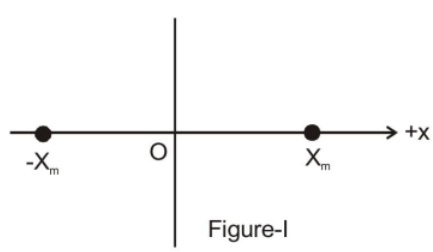


Figure-I

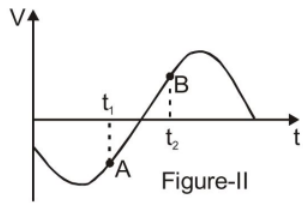


Figure-II

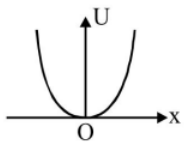
(A) At time t_1 , it is going towards X_m.

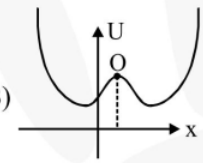
(B) At time t_1, its speed is decreasing.

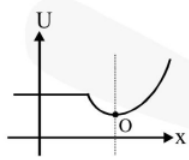
(C) At time t_2, its position lies in between – X_m and O.

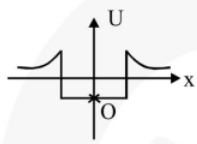
(D) The phase difference $\Delta\phi$ between points A and B must be expressed as $90° < \Delta\phi < 180°$.

Q4. Potential energy vs displacement graph is given for different situations, then for a small displacement about position 'O' in which of the following motion is S.H.M. :-

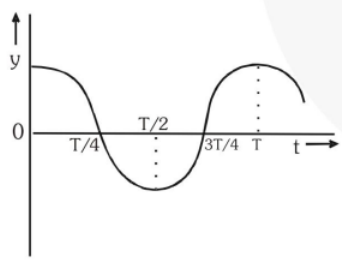
(A) 

(B) 

(C) 

(D) 

Q5. The displacement-time graph of a particle executing SHM is shown.



Which of the following statements is/are true?

(A) The velocity is maximum at t = T/2

(B) The acceleration is maximum at t = T

(C) The force is zero at t = 3T/4

(D) The potential energy equals the oscillation energy at t = T/2.

Q6. Two particles are in SHM with same amplitude A and same angular frequency ω.

At time t = 0, one is at $x = +\frac{A}{2}$ and other is at $x = -\frac{A}{2}$. Both are moving in same direction.

(A) Phase difference between the two particle is $\frac{\pi}{3}$

(B) Phase difference between the two particle is $\frac{2\pi}{3}$

(C) They will collide after time $t = \frac{\pi}{2\omega}$

(D) They will collide after time $t = \frac{3\pi}{\omega}$

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q7. A body of mass m attached to a spring which is oscillating with time period 4 seconds. If the mass of the body is increased by 4 kg, its time period increases by 2 sec. Determine value of initial mass m in Kg.

SUBJECTIVE TYPE

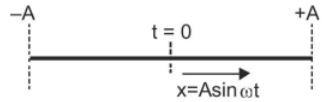
Q8. If two S.H.M.'s are represented by equations

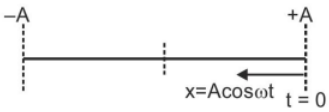
$$y_1 = 10\sin\left[3\pi t + \frac{\pi}{4}\right]$$

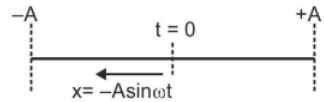
and $y_2 = 5\left[\sin(3\pi t) + \sqrt{3}\cos(3\pi t)\right]$

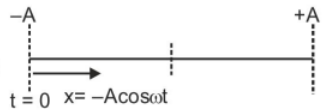
then find the ratio of their amplitudes and phase difference in between them.

Q9. What will be the equation of displacement in the following different conditions ?

(i) 

(ii) 

(iii) 

(iv) 

Q10. An object performs S.H.M. of amplitude 5 cm and time period 4 s. If timing is started when the object is at the centre of the oscillation i.e., x = 0 then calculate.

(a) Frequency of oscillation

(b) The displacement at 0.5 sec.

(c) The maximum acceleration of the object.

(d) The velocity at a displacement of 3 cm.

Q11. Amplitude of a harmonic oscillator is A, when velocity of particle is half of maximum velocity, then determine position of particle.

Q12. In case of simple harmonic motion –

(a) What fraction of total energy is kinetic and what fraction is potential when displacement is one half of the ampli-tude.

(b) At what displacement the kinetic and potential energies are equal.

Q13. A spring of force constant k is cut into two unequal parts ℓ_1 and ℓ_2, where $\frac{\ell_1}{\ell_2} = \frac{n_1}{n_2}$ then determine force constant of each part.

Q14. A block of mass m is suspended from a spring of spring constant k and released from rest at natural length. Find the amplitude of S.H.M.

Q15. The length of a second's pendulum at the surface of earth is 1m. Determine the length of second's pendulum at the surface of moon.

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. A particle executes simple harmonic motion between x = –A and x = +A. The time taken for it to go from O to $\frac{A}{2}$ is T_1 and to go from $\frac{A}{2}$ to A is T_2, then :-

(A) $T_1 < T_2$ (B) $T_1 > T_2$

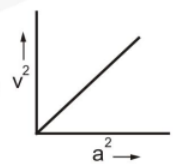
(C) $T_1 = T_2$ (D) $T_1 = 2T_2$

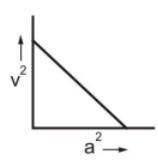
Q2. A particle performing S.H.M. is found at its equilibrium at t = 1 s and it is found to have a speed of 0.25 m/s at t = 2 s. If the period of oscillation is 6s Calculate amplitude of oscillation

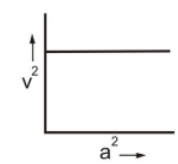
(A) $\frac{3}{2\pi}$ m (B) $\frac{3}{4\pi}$ m

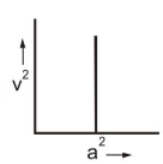
(C) $\frac{6}{\pi}$ m (D) $\frac{3}{8\pi}$ m

Q3. A mass M is performing linear simple harmonic motion, then correct graph for acceleration 'a' and corresponding linear velocity 'v' is

(A) 

(B) 

(C) 

(D) 

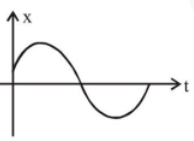
Q4. A particle performs SHM with a period T and amplitude a. The mean velocity of the particle over the time interval during which it travels a distance a/2 from the extreme position is

(A) a/T (B) 2a/T

(C) 3a/T (D) a/2T

Q5. A particle performing S.H.M. about mean position x = 0 and at t = 0 it is at position $x = \frac{A}{\sqrt{2}}$ and moving towards the origin. Then which of the following is its possible graph between position (x) and time (t)

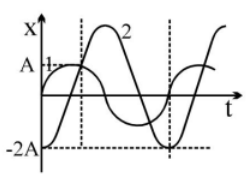
(A)

(B) 

(C)

(D)

Q6. The oscillations represented by curve 1 in the graph are expressed by equation x = A sinωt. The equation for the oscillations represented by curve 2 is expressed as:



(A) x = 2A sin (ωt – π/2)

(B) x = 2A sin (ωt + π/2)

(C) x = – 2A sin (ωt – π/2)

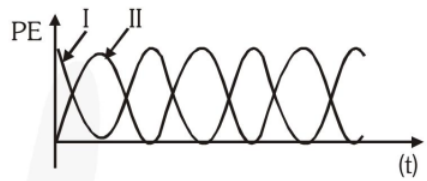
(D) x = A sin (ωt – π/2)

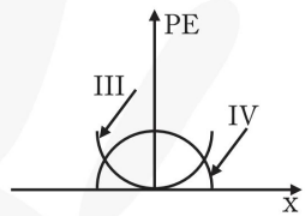
Q7. The total vibrational energy of a particle in S.H.M. is E. Its kinetic energy at half the amplitude from mean position will be :

(A) E/2 (B) E/3

(C) E/4 (D) 3E/4

Q8. For a particle executing SHM the displacement x given by x = Acosωt. Identify the graph which represents the variation of potential energy (PE) as a function of time t and displacement x :-

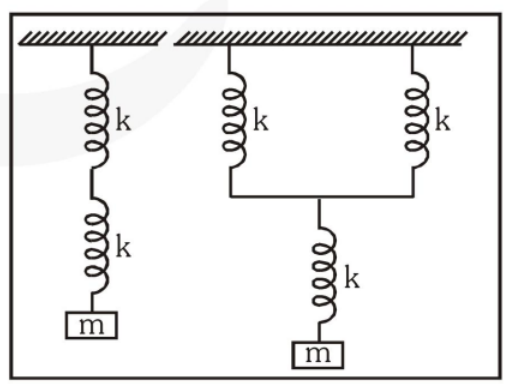




(A) I, III (B) II, IV

(C) II, III (D) I, IV

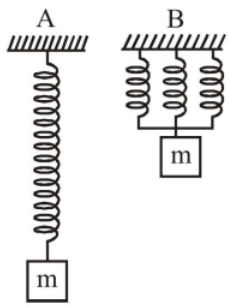
Q9. Some springs are combined in series and parallel arrangement as shown in the figure and a mass m is suspended from them. The ratio of their frequencies will be :



(A) 1 : 1 (B) 2 : 1

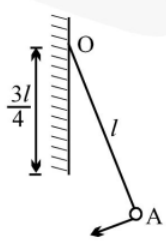
(C) $\sqrt{3}$: 2 (D) 4 : 1

Q10. The springs in figure A and B are identical but length of spring in A is three times than the length of each spring in B. The ratio of period T_A/T_B is :-



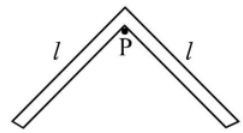
(A) $\sqrt{3}$ (B) 1/3
(C) 3 (D) $1/\sqrt{3}$

Q11. A small bob attached to a light inextensible thread of length *l* has a periodic time T when allowed to vibrate as a simple pendulum. The thread is now suspended from a fixed end O of a vertical rigid rod of length $\frac{3l}{4}$ (as in figure). If now the pendulum performs periodic oscillations in this arrangement, the periodic time will be



(A) $\frac{3T}{4}$ (B) $\frac{T}{2}$
(C) T (D) 2T

Q12. A system of two identical rods (L-shaped) of mass *m* and length *l* are resting on a peg P as shown in the figure. If the system is displaced in its plane by a small angle θ, find the period of oscillations:



(A) $2\pi\sqrt{\frac{2l}{3g}}$ (B) $2\pi\sqrt{\frac{2\sqrt{2}l}{3g}}$
(C) $2\pi\sqrt{\frac{2l}{3g}}$ (D) $3\pi\sqrt{\frac{l}{3g}}$

Q13. Two simple harmonic motions $y_1 = A\sin\omega t$ and $y_2 = A\cos\omega t$ are superimposed on a particle of mass m. The total mechanical energy of the particle is:

(A) $\frac{1}{2}m\omega^2A^2$ (B) $m\omega^2A^2$
(C) $\frac{1}{4}m\omega^2A^2$ (D) zero

Q14. The time taken by a particle performing SHM on a straight line to pass from point A to B where its velocities are same is 2 seconds. After another 2 seconds it returns to B. The time period of oscillation is (in seconds)

(A) 2 (B) 8
(C) 6 (D) 4

Q15. The period of oscillation of simple pendulum of length L suspended from the roof of the vehicle which moves without friction, down an inclined plane of inclination α, is given by :-

(A) $2\pi\sqrt{\frac{L}{g\cos\alpha}}$ (B) $2\pi\sqrt{\frac{L}{g\sin\alpha}}$
(C) $2\pi\sqrt{\frac{L}{g}}$ (D) $2\pi\sqrt{\frac{L}{g\tan\alpha}}$

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A horizontal plank has a rectangular block placed on it. The plank starts oscillating vertically and simple harmonically with an amplitude of 40 cm. The block just loses contact with the plank when the latter is at momentary rest. Then :

(A) the period of oscillation is $\left(\frac{2\pi}{5}\right)$

(B) the block weighs double of its weight, when the plank is at one of the positions of momentary rest

(C) the block weighs 0.5 times its weight on the plank halfway up

(D) the block weighs 1.5 times its weight on the plank halfway down

Q2. For a SHM with given angular frequency, two arbitrary initial conditions are necessary and sufficient to determine the motion completely. These initial conditions may be-

(A) Amplitude and initial phase

(B) Amplitude and total energy of oscillation

(C) Initial phase and total energy of oscillation

(D) Initial position and initial velocity

Q3. For a body executing SHM with amplitudes A, time period T, max velocity v_{max} and phase constant zero, which of the following statements are correct?

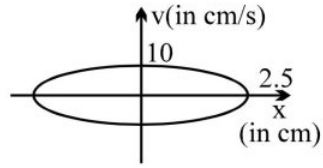
(A) At $y = (A/2)$, $v > (v_{max}/2)$

(B) $v = (v_{max}/2)$ for $y > (A/2)$

(C) For $t = (T/8)$, $y > (A/2)$

(D) For $y = (A/2)$, $t < (T/8)$

Q4. The figure shows a graph between velocity and displacement (from mean position) of a particle performing SHM:



(A) The time period of the particle is 1.57s

(B) The maximum acceleration will be 40 cm/s^2

(C) The velocity of particle is $2\sqrt{21}$ cm/s when it is at a distance 1 cm from the mean position.

(D) None of these

Q5. The amplitude of a particle executing SHM about O is 10 cm . Then :

(A) when the kinetic energy is 0.64 times of its max. kinetic energy its displacement is 6 cm from O

(B) when the displacement is 5 cm from O its kinetic energy is 0.75 times its maximum kinetic energy

(C) Its total energy of SHM at any point is equal to its maximum kinetic energy

(D) Its speed is half the maximum speed when its displacement is half the maximum displacement

Q6. A system is oscillating with undamped simple harmonic motion. Then the

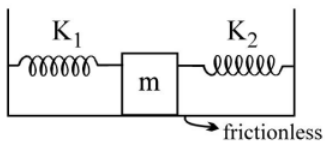
(A) average total energy per cycle of the motion is its maximum kinetic energy.

(B) average total energy per cycle of the motion is $\frac{1}{\sqrt{2}}$ times its maximum kinetic energy.

(C) root mean square velocity is $\frac{1}{\sqrt{2}}$ times its maximum velocity

(D) mean velocity is 1/2 of maximum velocity.

Q7. Two springs with negligible masses and force constant of $K_1 = 200\ Nm^{-1}$ and $K_2 = 160\ Nm^{-1}$ are attached to the block of mass m = 10 kg as shown in the figure. Initially the block is at rest, at the equilibrium position in which both springs are neither stretched nor compressed. At time t = 0, a sharp impulse of 50 Ns is given to the block with a hammer.



(A) Period of oscillations for the mass m is $\frac{\pi}{3}$ s.

(B) Maximum velocity of the mass m during its oscillation is 5 ms^{-1}.

(C) Data are insufficient to determine maximum velocity.

(D) Amplitude of oscillation is 0.42 m.

Q8. A mass of 0.2kg is attached to the lower end of a massless spring of force-constant 200 N/m, the upper end of which is fixed to a rigid support. Which of the following statements is/are true?

(A) In equilibrium, the spring will be stretched by 1cm.

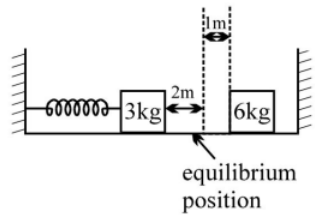
(B) If the mass is raised till the spring is unstretched state and then released, it will go down by 2cm before moving upwards.

(C) The frequency of oscillation will be nearly 5 Hz.

(D) If the system is taken to the moon, the frequency of oscillation will be the same as on the earth.

Q9. Two blocks of masses 3 kg and 6 kg rest on a horizontal smooth surface.

The 3 kg block is attached to a spring with a force constant k = 900 Nm^{-1} which is compressed 2 m from beyond the equilibrium position. The 6 kg mass is at rest at 1m from mean position. 3kg mass strikes the 6 kg mass and the two stick together.



(A) velocity of the combined masses immediately after the collision is 10 ms^{-1}

(B) velocity of the combined masses immediately after the collision is 5 ms^{-1}

(C) Amplitude of the resulting oscillation is $\sqrt{2}$ m

(D) Amplitude of the resulting oscillation is $\sqrt{5}/2$ m.

Q10. A particle moves in the x-y plane according to the equation, $\vec{r} = (\hat{i} + 2\hat{j})A\cos\omega t$. The motion of the particle is-

(A) on a straight line

(B) on an ellipse

(C) periodic

(D) simple harmonic

Q11. A particle is subjected to two simple harmonic motions along x and y directions according to, $x = 3\sin 100\pi t$; $y = 4\sin 100\pi t$.

(A) Motion of particle will be on ellipse traversing it in clockwise direction

(B) Motion of particle will be on a straight line with slope 4/3

(C) Motion will be simple harmonic motion with amplitude 5

(D) Phase difference between two motions is $\pi/2$

Q12. A particle free to move along the x-axis has potential energy given by :

$U(x) = k[1 - \exp(-x^2)]$ for $-\infty \le x \le +\infty$, where k is a positive constant of appropriate dimensions.

Then :-

(A) at points away from the origin, the particle is in unstable equilibrium

(B) for any finite non-zero value of x, there is a force directed away from the origin

(C) if its total mechanical energy is $\frac{k}{2}$, it has its minimum kinetic energy at the origin

(D) for small displacements from x = 0, the motion is simple harmonic.

Q13. A simple pendulum has time period T_1. The point of suspension is now moved upward according to the relation $y = Kt^2$, $(K = 1\ m/s^2)$ where y is the vertical displacement. The time period now becomes T_2. The ratio of $\frac{T_1^2}{T_2^2}$ is : $(g = 10\ m/s^2)$

(A) $\frac{6}{5}$ (B) $\frac{5}{6}$

(C) 1 (D) $\frac{4}{5}$

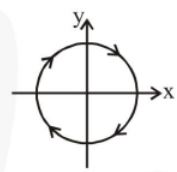
PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for question no. 14 and 15

Lissajous figures are produced by superposition of 2 SHM's in mutually perpendicular directions. If both SHM have same frequency, the lissajous figure is simple. It may be a circle, ellipse or a straight line depending on the phase difference between two SHMs. Interesting case occurs when one of the SHM is at double frequency of another. Suppose a body executes SHM vertically with frequency f_0, but horizontally with a frequency $2f_0$ and is initially at A, mean position of vertical as well as horizontal SHM. It can be seen to trace out a figure of 8 in space as shown. Since horizontal SHM has half the time period, it executes two horizontal oscillations by the time it completes a vertical oscillation.

Q14. A lissajous figure as shown here can be produced by



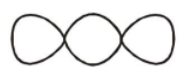
(A) $x = A \sin \omega t\ ;\ y = A \cos \omega t$

(B) $x = A \cos \omega t\ ;\ y = A \sin \omega t$

(C) $x = A \sin \omega t\ ;\ y = A \sin \left(\omega t + \frac{\pi}{4}\right)$

(D) $x = A \sin \omega t\ ;\ y = A \sin \left(\omega t + \frac{3\pi}{4}\right)$

Q15. For the Lissajous figure shown here, the frequency in vertical direction is _____ times the frequency in horizontal direction.

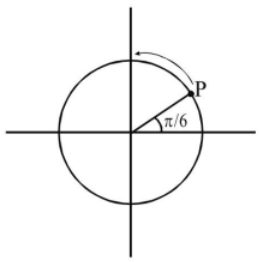
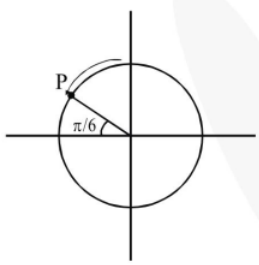
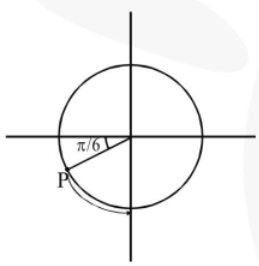
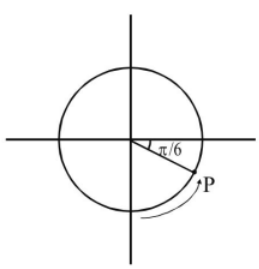


(A) 3 (B) $\frac{1}{3}$ (C) 2 (D) $\frac{1}{2}$

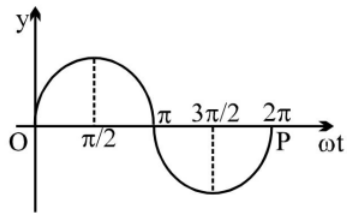
MATCH THE COLUMN TYPE

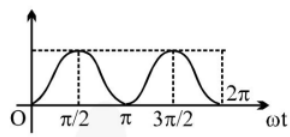
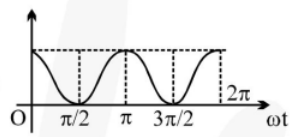
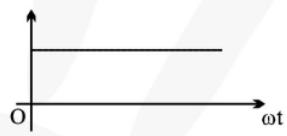
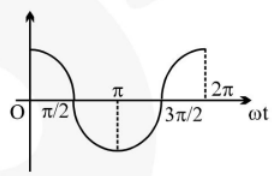
*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q16. All the phasor diagrams in column I are representing SHM, which has same time period, same amplitude and same angular frequency. The phasor moves in anticlockwise direction and projections on vertical diameter of reference circle represent SHM.

Column-I	**Column-II**
(A) 	(P) Equilibrium position is reached earliest.
(B) 	(Q) Acceleration is towards mean position.
(C) 	(R) Speed is increasing.
(D) 	(S) Velocity will reversed its direction in T/4 time
	(T) It crosses mean position in time interval T/6.

Q17. The graph plotted between phase angle (ϕ) and displacement of a particle from equilibrium position (y) is a sinusoidal curve as shown below. Then the best matching is :-



Column-I	Column-II
(A) K.E. versus phase angle curve	(P) 
(B) P.E. versus phase angle curve	(Q) 
(C) T.E. versus phase angle curve	(R) 
(D) Velocity versus phase angle curve	(S) 

SUBJECTIVE TYPE

Q18. Periodic time of oscillation T_1 is obtained when a mass is suspended from a spring if another spring is used with same mass then periodic time of oscillation is T_2. Now if this mass is suspended from series combination of above springs then calculate the time period.

Q19. A block is on a horizontal slab which is moving horizontally and executing S.H.M. The coefficient of static friction between block and slab is μ. If block is not separated from slab then determine angular frequency of oscillation.

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	B	A	C	A	B	D	A	A	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**		
C	A	C	A	B	A	D	B		

Ex-1A

1. C,D **2.** A **3.** B, C **4.** A,C **5.** B,C,D

6. A, C **7.** 3.2 kg **8.** 1 : 1, $-\frac{\pi}{12}$

10. (A) 0.25 Hz (B) $\frac{5}{\sqrt{2}}$ cm (C) 12.3 cm/s^2 (D) ±6.28 cm/s **11.** $x = \frac{\sqrt{3}A}{2}$

12. (a) $\frac{3}{4}, \frac{1}{4}$ (b) $\pm\frac{A}{\sqrt{2}}$ **13.** $k_1 = k\left[1+\frac{n_2}{n_1}\right], k_2 = k\left[1+\frac{n_1}{n_2}\right]$

14. $\frac{2mg}{k}$ **15.** $\ell_m = \frac{\ell_e}{6} = \frac{1}{6}$ m

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	A	B	C	A	A	D	A	C	C
11	**12**	**13**	**14**	**15**					
A	B	B	B	A					

Ex-2A

1. A,B,C,D **2.** A, C, D **3.** A,B,C,D **4.** A,B,C **5.** A,B,C

6. A,C **7.** A,B **8.** A,B,C,D **9.** A,C **10.** C,D

11. B,C **12.** D **13.** A **14.** A **15.** A

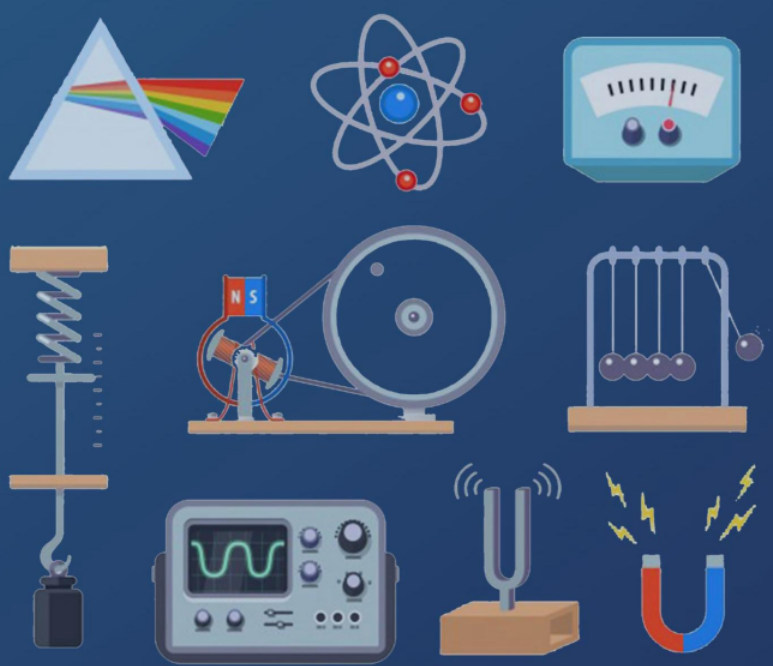
16. (A) -Q, S ; (B) -P,Q,R,T ; (C) -Q,S ; (D) -P,Q,R,T

17. (A) -Q, (B) -P, (C) -R, (D) -S **18.** $\sqrt{T_1^2 + T_2^2}$ **19.** $\omega \le \sqrt{\frac{\mu g}{A}}$

-: Important Notes & Formulas :-

PHYSICS

Sound Wave



SHEET

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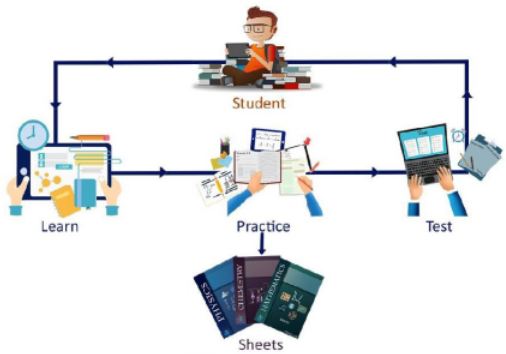
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Introduction to sound wave				
2	Equation of sound wave				1-3
3	Speed of sound wave	1-3	1,7,10	1-5	
4	Intensity of sound				4-6
5	Standing wave part 1				
6	Standing wave part 2	4-6	3	6-9	10-12,15
7	Resonance tube experiment	7-9	11	10-12	7
8	Doppler's effect	10-17			
9	Doppler's effect formula		4,12	13,14	13,14
10	Applications of Doppler's Effect	18	13	15-21	16,17
11	Interference	19-21	5,6,14	22	8
12	Beats	22,23	2,15	23-28	9

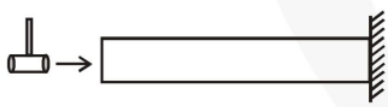
Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Speed of sound wave

Q1. A 1000 m long rod of density 10.0×10^4 kg/m^3 and having young's modulus Y = 10^{11} Pa, is clamped at one end. It is hammered at the other free end as shown in the figure. The longitudinal pulse goes to right end, gets reflected and again returns to the left end. How much time (in sec) the pulse take to go back to initial point?



(A) 4 s (B) 6 s
(C) 2 s (D) 10 s

Q2. At the room temperature the velocity of sound in O_2 gas is V. Then in mixture of H_2 and O_2 gas the speed of sound at same temprature:
(A) will be less than V
(B) will be more than V
(C) will be equal to V
(D) nothing can be said

Q3. Two monatomic ideal gases 1 and 2 of molecular masses m_1 and m_2 respectively are enclosed in separate container kept at the same temperature. The ratio of the speed of sound in gas 1 to that in gas 2 is given by :

(A) $\sqrt{\frac{m_1}{m_2}}$ (B) $\sqrt{\frac{m_2}{m_1}}$

(C) $\frac{m_1}{m_2}$ (D) $\frac{m_2}{m_1}$

Standing wave part-2

Q4. If the fundamental frequency for a Closed Organ Pipe is n, then the next three overtones will have ratio :-
(A) 2 : 3 : 4
(B) 3 : 4 : 5
(C) 3 : 7 : 11
(D) 3 : 5 : 7

Q5. A tube, closed at one end and containing air, produces, when excited, the fundamental note of frequency 512 Hz. If the tube is open at both ends,the fundamental frequency that can be excited is (in Hz).
(A) 1024 (B) 512
(C) 256 (D) 128

Q6. The velocity of sound in air is 330 m/s the fundamental frequency of an organ pipe open at both ends and length 0.3 metre will be :
(A) 200 Hz (B) 550 Hz
(C) 300 Hz (D) 275 Hz

Resonance tube experiment

Q7. The end correction of resonance tube is 1 cm. If lowest resonant length is 15 cm then next resonant lenght will be :-
(A) 36 cm (B) 45 cm
(C) 46 cm (D) 47 cm

Q8. An air column in pipe,which is closed at one end will be in resonance with a vibrating tuning fork of frequency 264 Hz if the length of the column in cm is : [v = 330 m/s]
(A) 31.25 (B) 62.50
(C) 110 (D) 125

Q9. If l_1 and l_2 are the lengths of air column for the first and second resonance when a tuning fork of frequency n is sounded on a resonance tube, then the distance of the displacement antinode from the top end of the resonance tube is :

(A) $2(l_2 - l_1)$ (B) $\frac{l}{2}(2l_1 - l_2)$

(C) $\frac{l_2 - 3l_1}{2}$ (D) $\frac{l_2 - l_1}{2}$

Doppler's effect formula

Q10. A siren blown in workshop emits waves of frequency 1000 Hz. A car driver approaches the workshop with velocity 90 km/hour then frequency of sound heard by driver will be in Hz. ($v_{sound} = 330\,m/s$)

(A) 926 (B) 1076

(C) 1176 (D) 1000

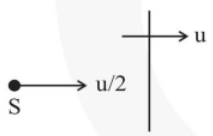
Q11. A wall is moving with velocity u and a source of sound moves with velocity u/2 in the same direction as shown in the figure. Assuming that the sound travels with velocity 10u, the ratio of incident sound wavelength on the wall to the reflected sound wavelength by the wall is equal to

(A) 9 : 11

(B) 11 : 9

(C) 4 : 5

(D) 5 : 4



Q12. A source of sound of frequency n and a listener approach each other with a velocity equal to $\frac{1}{20}$ of velocity of sound. The apparent frequency heard by the listener is:

(A) $\left(\frac{21}{19}\right)n$ (B) $\left(\frac{20}{21}\right)n$

(C) $\left(\frac{21}{20}\right)n$ (D) $\left(\frac{19}{20}\right)n$

Q13. A person observes a change of 2.5% in frequency of sound of horn of a car. If the car is approaching toward the person & sound velocity is 320 m/sec., then velocity of car in m/sec will be approximately.

(A) 8 (B) 800

(C)7 (D) 6

Q14. Two sound sources (of same frequency) are placed at distance of 100 meter. An observer when moving between both sources hears 4 beats per second. The distance between sound source is now changed to 400 meter then the beats/second heard by observer will be :

(A) 2 (B) 4

(C) 8 (D) 16

Q15. A railway engine moving with a speed of 60 m/sec passes in front of a stationary listener. The real freq. of whistle is 400 Hz. Calculate the apparant freq. heared by listner (a) when the engine is approaching the listener. (b) when the engine moving away from the listner (v_{sound} = 340 m/sec)

(A) 484 Hz, 340 Hz

(B) 220 Hz, 180 Hz

(C) 320 Hz,155 Hz

(D) 400 Hz, 330 Hz

Q16. A train moving towards a hill at a speed of 72 km / hr sounds a whistle of frequency 500 Hz. A wind is blowing from the hill at a speed of 36 km / hr. If the speed of sound in air is 340 m / s, the frequency heard by a man on the hill is

(A) 532.25 Hz.

(B) 565.0 Hz.

(C) 516.1 Hz.

(D) none of the above.

Q17. A source of sound of frequency 600 Hz is placed inside water. The speed of sound in water is 1500 m/s and in air it is 300 m/s. The frequency of sound recorded by an observer who is standing in air is :-

(A) 200 Hz (B) 3000 Hz

(C) 120 Hz (D) 600 Hz

Applications of Doppler's Effect

Q18. A man standing between two cliffs claps his hands and starts hearing a series of echoes at intervals of 2 sec. since the speed of sound in air is 340 m/sec. The distance between the cliffs must be:

(A) 340 m (B) 680 m

(C) 1020 m (D) 170 m

Interference

Q19. The ratio of maximum to minimum intensity due to superposition of two waves is $\frac{49}{9}$. Then the ratio of the intensity of component waves is :-

(A) $\frac{25}{4}$ (B) $\frac{16}{25}$

(C) $\frac{4}{49}$ (D) $\frac{9}{49}$

Q20. The energy in the superposition of waves :

(A) Is lost

(B) Increase

(C) remain same, only redistribution occurs

(D) None of the above

Q21. Two waves of intensities ratio are 9:1 then the ratio of their maximum and minimum intensities will be :-

(A) 10 : 8 (B) 7 : 2

(C) 4 : 1 (D) 2 : 1

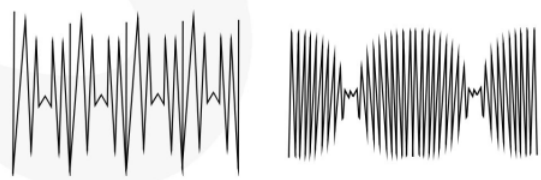
Beats

Q22. A tuning fork A produces 4 beats/sec with another tuning fork B of frequency 288 Hz. If fork is loaded with little wax. No of beats per sec decreases. The frequency of the fork A, before loading is -

(A) 290 Hz (B) 288 Hz

(C) 292 Hz (D) 284 Hz

Q23. Two waves with similar frequencies are added. The resulting waveform oscillates with the average frequency and with an oscillating amplitude that changes with a frequency equal to the difference between the original frequencies. These oscillations in the amplitude are known as beats. The traces show the resulting waveforms that occur when two different pairs of waves are added. Graph is for the same time interval in both cases, which of the following statements is TRUE?



(A) On average, the waves on the left had higher frequencies, but the difference between frequencies less

(B) On average, the waves on the right had higher frequencies, but the difference between frequencies less

(C) On average, the waves on the left had higher frequencies, but the difference between frequencies more

(D) On average, the waves on the right had higher frequencies, but the difference between frequencies more

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Which of the following statements are wrong about the velocity of sound in air:
(A) decreases with increases in temperature
(B) increases with decrease in temperature
(C) decreases as humidity increases
(D) independent of density of air

Q2. Three coherent source kept along the same line produce intensity I_0 each at point P on this line. When S_1 & S_2 are switched on simultaneously, intensity at point P is $2I_0$. When S_2 and S_3 are switched on simultaneously, intensity at point P is $2I_0$. Then -
(A) When S_1 and S_3 are switched on simultaneously, intensity at point P can be $2I_0$
(B) When S_1 and S_3 are switched on simultaneously, intensity at point P can be 0
(C) When all 3 sources are switched on simultaneously, intensity at point P can be I_0
(D) When all 3 sources are switched on simultaneously, intensity at point P can be $3I_0$

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q3. Third overtone of a closed organ pipe is in unison with fourth harmonic of an open organ pipe. find the ratio of lengths of the pipes.

Q4. When both source and observer approach each other with a speed equal to the half the speed of sound, then determine the percentage change in frequency of sound as detected by the listener.

Q5. During interference phenomenon of two wave, it is observed that amplitude ratio of waves is 5 : 4. Find the maximum to minimum intensity ratio of resulting wave.

Q6. Two sound waves emitted by one sound source is approaching at a point through two paths. When path difference is 36 cm or 60 cm, the points are silence point. If speed of sound in air be 330 m/sec, then find the frequency of sound source.

SUBJECTIVE TYPE

Q7. Sound can be heard at great distances after rainfall. Explain.

Q8. A sound wave is propagating in given gaseous medium then plot graph between
(A) v_{gas} & T (B) v_{gas} & P
(C) v_{gas} & $\sqrt{T}$
[v_{gas} = Speed of sound in gas,
P = Pressure,
T = Temperature]
Also write down proper units on axis.

Q9. Use the formula $v = \sqrt{\frac{\gamma P}{\rho}}$ to explain why the speed of sound in air
(A) is independent of pressure.
(B) increases with temperature.
(C) increases with humidity.

Q10. A stone dropped from the top of a tower of height 300 m high splashes into the water of a pond near the base of the tower. When is the splash heard at the top, given that the speed of sound in air is 340 m s^{-1} ?
($g = 9.8\ ms^{-2}$)

Q11. A 20 cm long pipe is closed at one end. Which harmonic mode of the pipe is resonantly excited by 425Hz source ? Will the same source be in resonance with the pipe if both ends are open ?
(Speed of sound in air = 340 m/s)

Q12. A railway engine moving with a speed of 60 m/s passes a stationary listener. The real frequency of its whistle is 400 Hz. Calculate the apparent frequency heard by the listener.
(A) When the engine is approching the listener.
(B) When the engine is moving away from the listener.
(velocity of sound = 340 m/s)

Q13. A stationary source emits sound of frequency 1200 Hz. If wind blows at the speed of 0.1v, deduce
(A) The change in the frequency for a stationary observer on the wind side of the source.
(B) Report the calculations for the case when there is no wind but the observer moves at 0.1v speed towards the source.
(given : velocity of sound = v)

Q14. Two waves having same frequency and same amplitude are superimposed at a point. Find the phase difference between two waves if resultant amplitude is :
(A) 2a (B) $\sqrt{2}a$
(C) a (D) Zero

Q15. A Standard tuning fork contains frequency n_0, another TF n_A have 20% more compared to n_0, n_B 30% more compared to n_0. n_A & n_B have beat relation of 6 beat/sec, then determine n_0, n_A, n_B.

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

Each question has FOUR options for correct answer. ***ONLY ONE*** *of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. A firecracker exploding on the surface of a lake is heard as two sounds a time interval t apart by a man on a boat close to water surface. Sound travels with a speed u in water and a speed v in air. The distance from the exploding firecracker to the boat is

(A) $\frac{uvt}{u+v}$ (B) $\frac{t(u+v)}{uv}$

(C) $\frac{t(u-v)}{uv}$ (D) $\frac{uvt}{u-v}$

Q2. The speed of longitudinal wave is 100 times the speed of transverse wave in a taut brass wire. If the Young's modulus of brass is $1.0 \times 10^{11}\ N/m^2$, the stress in wire is :-
(A) $1.0 \times 10^7\ N/m^2$
(B) $1.0 \times 10^6\ N/m^2$
(C) $1.0 \times 10^5\ N/m^2$
(D) $1.0 \times 10^8\ N/m^2$

Q3. A is singing a note and at the same time B is also singing a note with 1/8th the frequency of A. The energies of the two sounds are equal. The displacement amplitude of the note of B is :
(A) same as that of A
(B) twice that of A
(C) four times that of A
(D) eight times that of A

Q4. Spherical sound waves are emitted uniformly in all directions from a point source. The variation in sound level SL as a function of distance r(> 0) from the source can be written as :-

(A) $SL = -b \log r^a$ (B) $SL = a - b \log r$

(C) $SL = a - b(\log r)^2$ (D) $SL = a - \frac{b}{r^2}$

Q5. The ratio of intensities between two coherent sound sources is 4 : 1. The difference of loudness in dB between maximum and minimum intensities, when they interfere in space is:

(A) 10 log 2 (B) 20 log 3

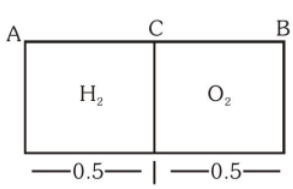
(C) 10 log 3 (D) 20 log 2

Q6. An open pipe is suddenly closed with the result that the second overtone of the closed pipe is found to be higher in frequency by 100 Hz, than the first overtone of the original pipe. Then the fundamental frequency of open pipe will be :

(A) 100 Hz (B) 300 Hz

(C)150 Hz (D) 200 Hz

Q7. As shown in fig AB is one metre long cylinder. At the ends A&B and middle point C there are thin flexible diaphragm. There is H_2 in AC and O_2 filled in part BC. diaphragm A & B are oscillated with some freq. When there is antinode at C then ratio of their minimum frequency n_{H_2} / n_{O_2} will be: (V_{H_2} = 1100 m /sec), V_{O_2} = 300 m/sec



(A) 11/3 (B) 11/7 (C) 9/7 (D) 9/11

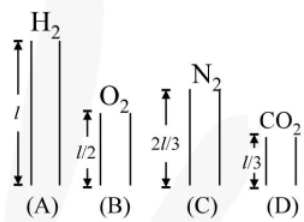
Q8. A closed organ pipe of length 1.5 m have some gas in it vibrating in fandamantal mode. Another open organ pipe of same length but filled with air, resonates with the same fork in its fundamental mode. If the temperature of the room be 30°C and the speed of sound in air at 30°C be 360 m/s, then speed of sound in the gas at 0°C is :

(A) 637 m/s (B) 683 m/s

(C) 341.5 m/s (D) 318 m/s

Q9. Four open organ pipes of different lengths and different gases at same temperature as shown in figure. Let f_A, f_B, f_C and f_D be their fundamental frequencies then :

[Take $\gamma_{CO_2} = 7/5$]



(A) $f_A/f_B = \sqrt{2}$ (B) $f_B/f_C = \sqrt{72/28}$

(C) $f_C/f_D = \sqrt{11/28}$ (D) $f_D/f_A = \sqrt{76/11}$

Q10. A cylindrical tube (L = 120 cm.) is resonant with a tuning fork of frequency 330 Hz. If it is filled by water then to get resonance minimum length of water column is-
(V_{air} = 330 m/s)

(A) 45 cm. (B) 60 cm.

(C) 25 cm. (D) 20 cm.

Q11. In a resonance tube experiment, an 80 cm air column is in resonance with a turning fork in first overtone. Which equation can represent correct pressure variation in the air column (x = 0 is the top point of the tube, neglect end correction, speed of sound = 320 m/sec) :-

(A) $A \sin \frac{15\pi}{8} x \cos 600\pi t$

(B) $A \cos \frac{15\pi}{8} x \sin 600\,\pi t$

(C) $A \cos \frac{15\pi}{8} x \sin 300\,\pi t$

(D) $A \sin \frac{15\pi}{8} x \sin 300\,\pi t$

Q12. In the experiment for the determination of the speed of sound in air using the resonance column method, the length of the air column that resonates in the fundamental mode, with a tuning fork is 0.1 m. When this length is changed to 0.35 m, the same tuning fork resonates with the first overtone. Calculate the end correction :-

(A) 0.012 m (B) 0.025 m

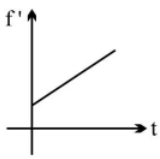
(C) 0.05 m (D) 0.024 m

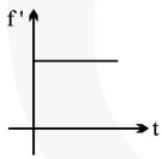
Q13. A source when at rest in a medium produces waves with a velocity v and a wavelength of λ . If the source is set in motion with a velocity v_s, what would be the wavelengths produced directly in front of the source?

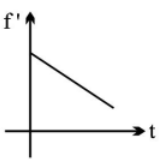
(A) $\lambda\left(1-\frac{v_s}{v}\right)$ (B) $\lambda\left(1+\frac{v_s}{v}\right)$

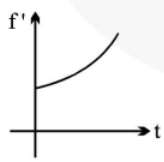
(C) $\lambda\left(1+\frac{v}{v_s}\right)$ (D) $\frac{\lambda v}{v+v_s}$

Q14. An observer starts moving with uniform acceleration 'a' towards a stationary sound source of frequency f. As the observer approaches the source, the apparent frequency f' heard by the observer varies with time t as :

(A) 

(B) 

(C) 

(D) 

Q15. An observer moves towards a stationary source of sound with a velocity one tenth the velocity of sound. The apparent increases in frequency is -

(A) zero (B) 5%

(C) 10% (D) 0.1%

Q16. A point source of sound is located somewhere along the x-axis. Experiments show that the same wave front simultaneously reaches listeners at x = –8 m and x = +2.0 m.

A third listener is positioned along the positive y-axis. What is her y-coordinate (in m) if the same wave front reaches her at the same instant as it does the first two listeners ?

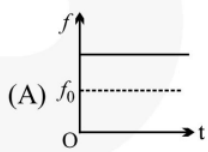
(A) 4 (B) 3 (C) 2 (D) 5

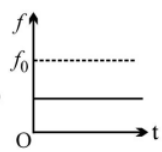
Q17. A source of sound S having frequency f. Wind is blowing from source to observer O with velocity u. If speed of sound with respect to air is C, the wavelength of sound detected by O is:

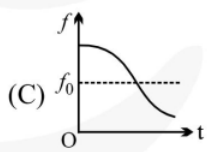
(A) $\frac{C+u}{f}$ (B) $\frac{C-u}{f}$

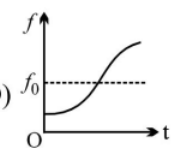
(C) $\frac{C(C+u)}{(C-u)f}$ (D) $\frac{C}{f}$

Q18. Source and observer both start moving simultaneously from origin, one along x-axis and the other along y-axis with speed of source = twice the speed of observer. The graph between the apparent frequency observed by observer f and time t would approximately be :

(A) 

(B) 

(C) 

(D) 

Q19. A siren placed at a railway platform is emitting sound of frequency 5 kHz. A passenger sitting in a moving train A records a frequency of 5.5 kHz while the train approaches the siren. During his return journey in a different train B he records a frequency of 6.0 kHz while approaching the same siren. The ratio of the velocity of train B to that of train A is :-

(A) 242/252 (B) 2

(C) 5/6 (D) 11/6

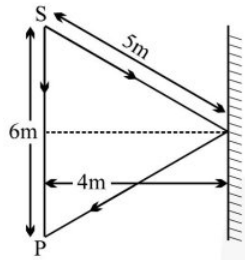
Q20. A person standing at a distance of 6 m from a source of sound receives sound wave in two ways, one directly from the source and other after reflection from a rigid boundary as shown in the figure. The maximum wavelength for which, the person will receive maximum sound intensity, is

(A) 4 m

(B) $\frac{16}{3}$ m

(C) 2 m

(D) $\frac{8}{3}$ m



Q21. A source is moving with constant speed $v_s = 20$ m/sec towards a stationary observer due east of source. Wind is blowing at the speed of 20 m/sec due to 60° north of east. The source is generating of frequency 500 Hz. Then frequency registered by observer is :
[Speed of sound in still air = 330 m/sec.]

(A) 500 Hz (B) 532 Hz

(C) 531 Hz (D) 530 Hz

Q22. The equations of S.H.M. of medium particle due to sound waves propagating in a medium are given by $s_1 = 2 \sin(200\pi t)$ and $s_2 = 5 \sin(150\pi t)$. The ratio of average intensities of sound at these points is :

(A) 4 : 25 (B) 9 : 100

(C) 8 : 15 (D) 64 : 225

Q23. Two waves of wave length 2 m and 2.02 m respectively moving with the same velocity superimpose to produce 2 beats per sec. The velocity of the wave is:

(A) 400.0 m/s (B) 402 m/s

(C) 404 m/s (D) 406 m/s

Q24. Frequency of tuning fork A is 256 Hz. It produces 4 beats/sec with tuning fork B. When wax is applied at tuning fork B then 6 beats/sec are heard. By reducing little amount of wax 4 beats/sec are heard. Frequency of B is :

(A) 250 Hz (B) 260 Hz

(C) 252 Hz (D) 256 Hz

Q25. Two wires are fixed in a sonometer. Their tensions are in the ratio 8:1. The lengths are in the ratio 36:35. the diameters are in the ratio 4:1. Densities of the materials are in the ratio 1:2. If the higher frequency in the setting is 360 Hz, the beat frequency when the two wires sounded together is :

(A) 8 (B) 5 (C) 10 (D) 6

Q26. A person is observing two trains. One of them is coming with speed of 4m/sec. and another is going with same speed. If two trains blowing a whistle with frequency 240 Hz. The beat frequency heard by stationary person will be (speed of sound in air = 320 m/sec.)

(A) zero (B) 3 (C) 6 (D) 12

Q27. Two vibrating tuning forks produce progressive waves given by $y_1 = 4 \sin(500\pi t)$ and $y_2 = 2 \sin(506\pi t)$. These tuning forks are held near the ear of a person. The person will hear :

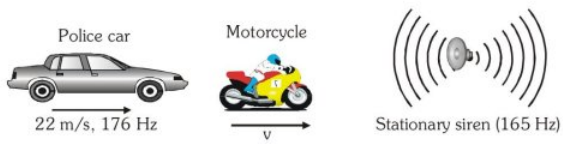
(A) 3 beats/s with intensity ratio between maxima and minima equal to 4.

(B) 3 beats/s with intensity ratio between maxima and minima equal to 9.

(C) 6 beats/s with intensity ratio between maxima and minima equal to 4.

(D) 6 beats/s with intensity ratio between maxima and minima equal to 9.

Q28. A police car moving at 22 m/s chases a motocyclist. The police man sounds his horn at 176 Hz, while both of them move towards a stationary siren of frequency 165 Hz. Calculate the speed of the motorcycle. If it is given that the motorcyclist does not observe any beats :–



(A) 33 m/s (B) 22 m/s

(C) zero (D) 11 m/s

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. A sound wave has a wavelength of 3.0 m. The distance from a compression center to the adjacent rarefaction center is :-

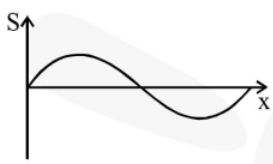
(A) 0.75 m

(B) 1.5 m

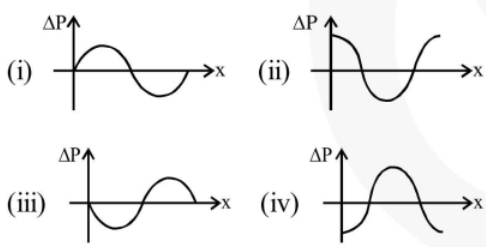
(C) 3.0 m

(D) need to know wave speed

Q2. If a sound wave is travelling and snap shot at t = 0 is as shown in figure.



Choose snapshot of pressure variation.



(A) For wave travelling towards right or left (i) is correct.

(B) For wave travelling towards right graph (iv) and for wave travelling towards left graph (iv) is correct.

(C) For wave travelling towards right graph (i) and for wave travelling towards left graph (iii) is correct.

(D) For wave travelling towards right or left (ii) is correct.

Q3. The particle displacement of a travelling longitudinal wave is represented by S = S (x, t). The midpoints of a compression zone and an adjacent rarefaction zone are represented by the letter 'C' and 'R'. Which of the following is true?

(A) $|\partial S / \partial x|_C = |\partial S / \partial x|_R$

(B) $|\partial S / \partial t|_C = |\partial S / \partial t|_R = 0$

(C) $(\text{pressure})_C - (\text{pressure})_R = 2\,|\partial S / \partial x|_C \times$ Bulk modulus of air.

(D) Particles of air are stationary mid-way between 'C' and 'R'.

Q4. Which of the following is the equation of a spherical wave :-

(A) $S = S_0 \sin(Kx - \omega t)$

(B) $S = S_0 \cos(Kx - \omega t)$

(C) $S = (S_0/x) \sin(\omega t - Kx)$

(D) $S = (S_0/x^2) \sin(\omega t - Kx)$

Q5. A note is produced when you blow air across the top of a test tube. Two students were asked about the effect of blowing harder.

Student-A : The pitch of sound would increase.

Student-B : The intensity of sound would increase.

(A) A is correct, B is wrong

(B) B is correct, A is wrong

(C) both are correct

(D) both are wrong

Q6. A person hears a single-frequency sound from a speaker that emits sound uniformly in all directions. The person records the decibel level reading. Which of the following processes would increase the decible reading the most ?

(A) The power output of the speaker is doubled.

(B) The frequency of the sound is doubled keeping amplitude constant.

(C) The temperature of the air is doubled on the Kelvin scale.

(D) The area over which the sound is transmitted is halved.

Q7. An open pipe is in resonance in 2nd harmonic with frequency f_1. Now one end of the tube is closed and frequency is increased to f_2 such that the resonance again occurs in nth harmonic. Choose the correct option :-

(A) $n = 3, f_2 = \frac{3}{4} f_1$ (B) $n = 3, f_2 = \frac{5}{4} f_1$

(C) $n = 5, f_2 = \frac{5}{4} f_1$ (D) $n = 5, f_2 = \frac{3}{4} f_1$

Q8. A sound consists of four frequencies : 300 Hz, 600 Hz, 1200 Hz and 2400 Hz. A sound 'filter' is made by passing this sound through a bifurcate pipe as shown. The sound wave has to travel a distance of 50 cm more in the right branch-pipe than in the straight pipe. The speed of sound in air is 300 m/s. Then, which of the following frequencies will be almost completely muffled or 'silenced' at the outlet?

(A) 300 Hz (B) 600 Hz
(C) 1200 Hz (D) 2400 Hz

Q9. Two tuning forks of frequency 250 Hz and 256 Hz produce beats. If a maximum of intensity is observed just now, after how much time the minimum is observed at the same place ?

(A) $\frac{1}{18}$ sec (B) $\frac{1}{4}$ sec.

(C) $\frac{1}{3}$ sec. (D) $\frac{1}{12}$ sec.

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 10 to 12

A metallic rod of length 1m has one end free and other end rigidly clamped. Longitudinal stationary waves are set up in the rod in such a way that there are total six antinodes present along the rod. The amplitude of an antinode is 4×10^{-6} m. Young's modulus and density of the rod are 6.4×10^{10} N/m^2 and 4×10^3 Kg/m^3 respectively. Consider the free end to be at origin and at t=0 particles at free end are at positive extreme.

Q10. The equation describing displacements of particles about their mean positions is -

(A) $s = 4\times10^{-6}\cos\left(\frac{11\pi}{2}x\right)\cos(22\pi\times10^3 t)$

(B) $s = 4\times10^{-6}\cos\left(\frac{11\pi}{2}x\right)\sin(22\pi\times10^3 t)$

(C) $s = 4\times10^{-6}\cos(5\pi x)\cos(20\pi\times10^3 t)$

(D) $s = 4\times10^{-6}\cos(5\pi x)\sin(20\pi\times10^3 t)$

Q11. The equation describing stress developed in the rod is -

(A) $140.8\pi\times10^4\cos\left(\frac{11}{2}\pi x+\pi\right)\cos(22\pi\times10^3 t)$

(B) $140.8\pi\times10^4\sin\left(\frac{11}{2}\pi x+\pi\right)\cos(22\pi\times10^3 t)$

(C) $128\pi\times10^4\cos(5\pi x+\pi)\cos(20\pi\times10^3 t)$

(D) $128\pi\times10^4\sin(5\pi x+\pi)\cos(20\pi\times10^3 t)$

Q12. The magnitude of strain at midpoint of the rod at t = 1 sec is -

(A) $11\sqrt{3}\pi\times10^{-6}$

(B) $11\sqrt{2}\pi\times10^{-6}$

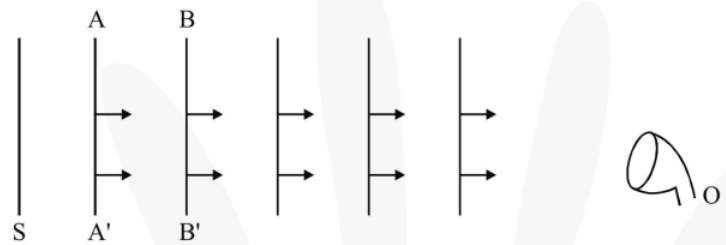
(C) $10\sqrt{3}\pi\times10^{-6}$

(D) $10\sqrt{2}\pi\times10^{-6}$

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q13. Consider a large plane diaphragm 'S' emitting sound and a detector 'O'. The diagram shows plane wavefronts for the sound wave travelling in air towards right when source, observer and medium are at rest. AA' and BB' are fixed imaginary planes. Column-I describes about the motion of source, observer or medium and column-II describes various effects. Match them correctly.



Column-I	Column-II
(A) Source starts moving towards right	(P) Distance between any two wavefronts will increase.
(B) Air starts moving towards right	(Q) Distance between any two wavefronts will decrease.
(C) Observer and source both move towards left with same speed.	(R) The time needed by sound to move from plane AA' to BB' will increase.
(D) Source and medium (air) both move towards right with same speed.	(S) The time needed by sound to move from plane AA' to BB' will decrease.
	(T) Frequency received by observer increases.

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q14. A bat is flitting about in a cave, navigating via ultrasonic bleeps. Assume that the sound emission frequency of the bat is 40 kHz. During one fast swoop directly toward a flat wall surface, the bat is moving at 0.03 times the speed of sound in air. What frequency does the bat hear reflected off the wall ?

SUBJECTIVE TYPE

Q15. Two narrow cylindrical pipes A and B have the same length. Pipe A is open at both ends and is filled with a monoatomic gas of molar mass M_A. Pipe B is open at one end and closed at the other end, and is filled with a diatomic gas of molar mass M_B. Both gases are at the same temperature.

(A) If the frequency of the second harmonic of the fundamental mode in pipe A is equal to the frequency of the third harmonic of the fundamental mode in pipe B, determine the value of M_A/M_B.

(B) Now the open end of pipe B is also closed (so that the pipe is closed at both ends). Find the ratio of the fundamental frequency in pipe A to that in pipe B.

Q16. A steel rod having a length of 1 m is fastened at its middle. Assuming young's modulus to be 2×10^{11} Pa and density to be 8 gm/cm^3, find the fundamental frequency of the longitudinal vibration and frequency of first overtone.

Q17. A car is moving towards a huge wall with a speed = c/10 , where c = speed of sound in still air. A wind is also blowing parallel to the velocity of the car in the same direction and with the same speed. If the car sounds a horn of frequency f, then what is the frequency of the reflected sound of the horn heard by driver of the car?

Answer Key

Ex-1

1	2	3	4	5	6	7	8	9	10
C	B	B	D	A	B	D	A	C	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	A	A	B	A	A	D	C	A	C
21	**22**	**23**							
C	C	B							

Ex-1A

1. A,B,C,D **2.** B,C **3.** 7/8 **4.** 200% **5.** 81:1

6. 1375 Hz **7.** Explainatory Question **8.** Explainatory Question

9. Explainatory Question **10.** 8.707 s **11.** first harmonic, NO

12. (A) 485.7 Hz, (B) 340 Hz **13.** (A) No change in frequency (B) 1320 Hz

14. (A)0°, (B)90°, (C)120°, (D)180° **15.** 60 Hz, 72 Hz, 78 Hz

Ex-2

1	2	3	4	5	6	7	8	9	10
D	A	D	B	B	D	A	B	C	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	B	A	A	C	A	A	B	B	A
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**		
C	D	C	B	C	C	B	B		

Ex-2A

1. B **2.** B **3.** A,C,D **4.** C **5.** B

6. B **7.** C **8.** A **9.** B,D **10.** A

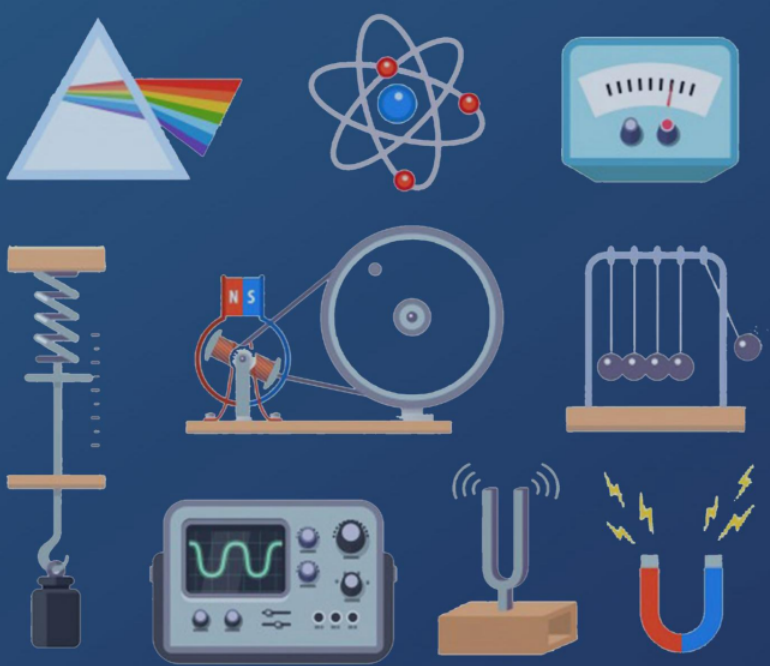
11. B **12.** B **13.** (A) (Q,T) ; (B) (P,S) ; (C) (P) (D) (S,T)

14. 42.47 Hz **15.** (A) 2.116, (B) $\frac{3}{4}$ **16.** 2.5 kHz, 7.5 kHz

17. 11f / 9

PHYSICS

Thermal Expansion



SHEET

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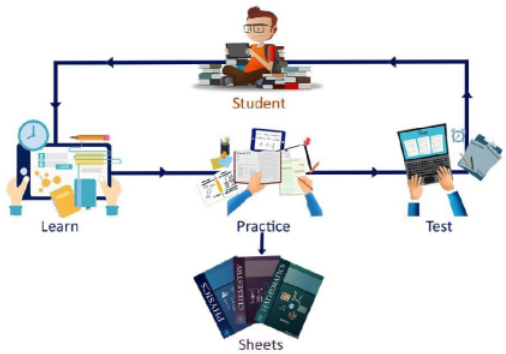
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Thermal Expansion-Introduction	1	7,8	1	
2	Coefficients of Expansion	2-5	1-5	2-4	1,10,11
3	Concepts Expansion	6,7	6		
4	Thermal Stress	8		5	2
5	After Full Chapter			6,7	3-9, 12

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Thermal Expansion-Introduction

Q1. The coefficient of linear expansion of copper is 17×10^{-6} $(°C)^{-1}$. A copper statue is 93 m tall on the summer morning of temperature 25°C. What is maximum order of increase in magnitude of the height in statue (maximum temperature of day is 45°C)

(A) 0.1 mm (B) 1 mm

(C) 10 mm (D) 100 mm

Coefficients of Expansion

Q2. The volume of a metal sphere increases by 0.24% when its temperature is raised by 40°C. The coefficient of linear expansion of the metal is .....°C

(A) 2×10^{-5} (B) 6×10^{-5}

(C) 2.1×10^{-5} (D) 1.2×10^{-5}

Q3. When a copper ball is heated, the largest percentage increase will occur in its

(A) Diameter (B) Area

(C) Volume (D) Density

Q4. A thin copper wire of length L increase in length by 1% when heated from temperature T_1 to T_2. What is the percentage change in area when a thin copper plate having dimensions $2L \times L$ is heated from T_1 to T_2?

(A) 1% (B) 2%

(C) 3% (D) 4%

Q5. If the length of a cylinder on heating increases by 2%, the area of its base will increase by

(A) 0.5% (B) 2%

(C) 1% (D) 4%

Concepts Expansion

Q6. A brass disc fits simply in a hole of a steel plate. The disc from the hole can be loosened if the system.

(A) First heated then cooled

(B) First cooled then heated

(C) Is heated

(D) Is cooled

Q7. Density of substance at 0°C is 10 gm/cc and at 100°C, its density is 9.7 gm/cc. The coefficient of linear expansion of the substance will be :-

(A) 10^2 °C^{-1}

(B) 10^{-2} °C^{-1}

(C) 10^{-3} °C^{-1}

(D) 10^{-4} °C^{-1}

Thermal Stress

Q8. If a bimetallic strip is heated, it will

(A) bend towards the metal with lower thermal expansion coefficient.

(B) bend towards the metal with higher thermal expansion coefficient.

(C) twist itself into helix.

(D) have no bending.

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Ratio among linear expansion coefficient (α), area expansion coefficient (β) and volume expansion coefficient (γ) is -

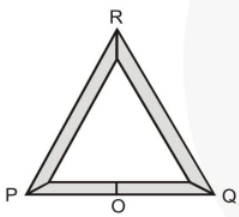
(A) 1 : 2 : 3

(B) 3 : 2 : 1

(C) 4 : 3 : 2

(D) none of these

Q2. Three rods of equal length ℓ are joined to form an equilateral triangle PQR. O is the mid point of PQ. Distance OR remains same for small change in temperature. Coeffcient of linear expansion for PR and RQ is same i.e. α_2 but that for PQ is α_1. Then



(A) $\alpha_2 = 3\alpha_1$ (B) $\alpha_1 = 4\alpha_2$

(C) $\alpha_1 = 3\alpha_2$ (D) $\alpha_2 = 4\alpha_1$

Q3. The coefficient of linear expansion of crystal in one direction is α_1 and that in every direction perpendicular to it is α_2,. The coefficient of cubical expansion is.

(A) $\alpha_1 + \alpha_2$

(B) $2\alpha_1 + \alpha_2$

(C) $\alpha_1 + 2\alpha_2$

(D) None of these

Q4. When the temperature of a copper coin is raised by 80°C, its diameter increases by 0.2%.

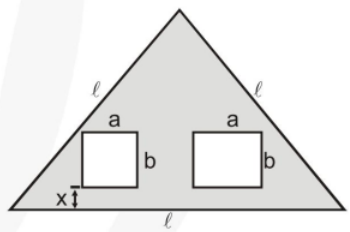
(A) Percentage rise in the area of a face is 0.4 %

(B) Percentage rise in the thickness is 0.4 %

(C) Percentage rise in the volume is 0.6 %

(D) Coefficient of linear expansion of copper is $0.25 \times 10^{-4}\ C^{\circ\ -1}$.

Q5. A triangular plate has two cavities, one square and one rectangular as shown in figure. The plate is heated.



(A) a increase, b decrease

(B) a and b both increase

(C) a and b increase, x and ℓ decrease

(D) a, b, x and ℓ all increase

Q6. Water has maximum density at

(A) 0°C (B) 32°F

(C) - 4°C (D) 4°C

SUBJECTIVE TYPE

Q7. A rod of length 2 m at 0°C and having expansion coefficient

$\alpha = (3x + 2) \times 10^{-6}\ °C^{-1}$,

where x is the distance (in cm) from one end of rod. The length of rod at 20°C is :

Q8. A hole is drilled in a copper sheet. The diameter of the hole is 4.24 cm at 27.0 °C. What is the change in the diameter of the hole when the sheet is heated to 227 °C ?

Coefficient of linear expansion of copper $= 1.70 \times 10^{-5}\ °C^{-1}$.

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. A gas follows VT^2 = const. Its volume expansion coefficient will be :-

(A) $\frac{2}{T}$ (B) $-\frac{2}{T}$

(C) $\frac{3}{T}$ (D) $-\frac{3}{T}$

Q2. Which of the following is true about coefficient of linear expansion for anisotropic solids?

(A) $\beta_{xy} = \alpha_x + \alpha_y$ (B) $\beta_{xz} = \alpha_x + \alpha_z$

(C) $\gamma = \alpha_x + \alpha_y + \alpha_z$ (D) All of these

Q3. Two rods one of aluminium of length l_1 having coefficient of linear expansion α_a and other steel of length l_2 having coefficient of linear expansion α_s are joined end to end. The expansion in both the rods is same on variation of temperature. Then the value of $\frac{l_1}{l_1+l_2}$ is -

(A) $\frac{\alpha_s}{\alpha_a+\alpha_s}$ (B) $\frac{\alpha_s}{\alpha_a-\alpha_s}$

(C) $\frac{\alpha_a+\alpha_s}{\alpha_s}$ (D) None of these

Q4. If two rods of length L and 2L having coefficients of linear expansion α and 2α respectively are connected so that total length becomes 3L, the average coefficient of linear expansion of the composition rod equals :

(A) $\frac{3}{2}\alpha$ (B) $\frac{5}{2}\alpha$

(C) $\frac{5}{3}\alpha$ (D) none of these

Q5. A rod of length 2 m is at a temperature of 20°C. Find the free expansion of the rod, if the temperature is increased to 50°C, then find stress produced when the rod is fully prevented to expand.
($Y = 2 \times 10^{11}$ N/m^2 ; $\alpha = 15 \times 10^{-6}$/°C)

(A) 9×10^7 N/m^2 (B) 3×10^7 N/m^2

(C) 6×10^7 N/m^2 (D) None of these

Q6. A wire of length L_0 is supplied heat to raise its temperature by T. If γ is the coefficient of volume expansion of the wire and Y is Young's modulus of the wire then the energy density stored in the wire is

(A) $\frac{1}{2}\gamma^2T^2Y$ (B) $\frac{1}{3}\gamma^2T^2Y^3$

(C) $\frac{1}{18}\frac{\gamma^2T^2}{Y}$ (D) $\frac{1}{18}\gamma^2T^2Y$

Q7. A rod of length 20 cm is made of metal. It expands by 0.075cm when its temperature is raised from 0°C to 100°C. Another rod of a different metal B having the same length expand by 0.045 cm for the same change in temperature. A third rod of the same length is composed of two parts, one of metal A and the other of metal B. This rod expands by 0.060 cm for the same change in temperature. The portion made of metal A has the length :

(A) 20 cm (B) 10 cm

(C) 15 cm (D) 18 cm

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. The volume of the bulb of a mercury thermometer at 0°C is V_0 and cross section of the capillary is A_0. The coefficient of linear expansion of glass is α_g per °C and the cubical expansion of mercury γ_m per °C. If the mercury just fills the bulb at 0°C, what is the length of mercury column in capillary at T°C.

(A) $\frac{V_0T(\gamma_m+3\alpha_g)}{A_0(1+2\alpha_gT)}$ (B) $\frac{V_0T(\gamma_m-3\alpha_g)}{A_0(1+2\alpha_gT)}$

(C) $\frac{V_0T(\gamma_m+2\alpha_g)}{A_0(1+3\alpha_gT)}$ (D) $\frac{V_0T(\gamma_m-2\alpha_g)}{A_0(1+3\alpha_gT)}$

Q2. A bimetallic strip is formed out of two identical strips one of copper and the other of brass. The coefficient of linear expansion of the two metals are α_C and α_B. On heating, the temperature of the strip goes up by ΔT and the strip bends to form an arc of radius of curvature R. Then R is

(A) proportional to ΔT

(B) inversely proportional to ΔT

(C) proportional to $|\alpha_B-\alpha_C|$

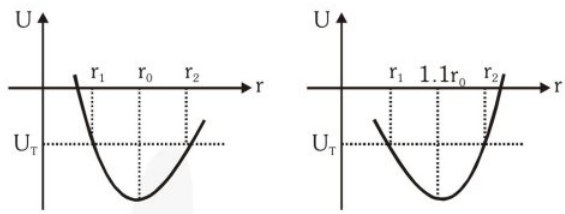
(D) inversely proportional to $|\alpha_B-\alpha_C|$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 3 to 5

Consider a hypothetical situation where we are comparing the properties of two crystals made of atom A and atom B. Potential energy (U) v/s interatomic separation (r) graph for atom A and atom B is shown in figure (i) and (ii) and respectively.



Q3. Choose correct statement :

(A) Volume of A and B expand on heating

(B) Volume of A and B contract on heating

(C) A expands on heating and B contracts on heating

(D) A contracts on heating and B expands on heating

Q4. When we heat the crystal of either atoms, the atom undergo oscillation. Choose correct statement for atoms of crystal A.

(A) Their equilibrium position remains unchanged but average separation decreases

(B) Their equilibrium position remains unchanged but average separation increases

(C) Their separation at equilibrium position as well as average separation increases

(D) Their separation at equilibrium position decreases but average separation increases

Q5. It is seen that the potential energy can reach a maximum value of U_T at temperature T = 10K. If r_1 and r_2 are 0.9999 r_0 and 1.0003 r_0 for atoms of crystal A, its approximate coefficient of linear expansion can be :-

(A) 4×10^{-5} /K (B) 1×10^{-5} /K

(C) 2×10^{-5} /K (D) 3×10^{-5} /K

Paragraph for Question No. 6 to 9

Most substances contract on freezing. However, water does not belong to this category. We know that water expands on freezing. Further, coefficient of volume expansion of water in the temperature range from 0°C to 4°C is negative and above 4°C it is positive. This behaviour of water shapes the freezing of lakes as the atmospheric temperature goes down and it is still above 4°C.

Q6. As the atmospheric temperature goes down, but it is still above 4°C

(A) Cooled water at the surface flows downward because of its greater density.

(B) Cooled water at the surface does not flow downward and remains at the surface because its smaller density.

(C) Cooled water at the surface, through it remains on the surface because of its smaller density, will conduct heat from the interior to the atmosphere.

(D) Cooled water at the surface flows to the bottom because of its smaller density.

Q7. As the atmospheric temperature goes below 4°C.

(A) Cooled water at the surface flows downward because of its greater density.

(B) Cooled water at the surface does not flow downward and remains at the surface because of its smaller density.

(C) Cooled water at the surface downward because of its smaller density.

(D) Temperature of water in the lake reduces with depth.

Q8. If the atmospheric temperature is below 0°C and ice begins to form at t = 0, thickness of ice sheet formed up to a time 't' will be directly proportional to -

(A) t^4 (B) t^2 (C) t (D) $t^{1/2}$

Q9. If the atmospheric temperature is below 0°C

(A) Ice will form from the bottom upward and the plants and animals in the lake will be displaced to the upper part of the lake.

(B) Ice will form in a random manner throughout the volume of the lake and with the passage of time, different segments of ice will join together to result in a collective ice mass

(C) Ice will form from the surface downward and plant and animal life will survive in the water beneath.

(D) Water in the lake does not freeze. In fact, water in the atmosphere freezes and fall into the lake and floats on the surface of lake as ice.

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q10. A pendulum clock is 5 sec fast at temperature of 15°C and 10 sec slow at a temperature of 30°C. At what temperature does it give the correct time :-

SUBJECTIVE TYPE

Q11. A clock pendulum made of invar has a period of 0.5 sec at 20°C. If the clock is used in a climate where average temperature is 30°C approximately. How much fast or slow will the clock run in 10^6 sec.

($\alpha_{invar}=1\times10^{-6}/°C$)

Q12. A rod AB of length 'ℓ' is pivoted at an end A and freely rotated in a horizontal plane at an angular speed ω about a vertical axis passing through A. If co-efficient of linear expansion of material of rod is α, find the percentage change in its angular velocity if temperature of system is increased by ΔT.

Answer Key

Ex-1							
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
C	A	C	B	D	D	D	A

Ex-1A

1. A **2.** B **3.** C **4.** A,C,D **5.** B,D

6. D **7.** 2.0002 m **8.** 1.44×10^{-2} cm

Ex-2						
1	**2**	**3**	**4**	**5**	**6**	**7**
B	D	A	C	A	D	B

Ex-2A

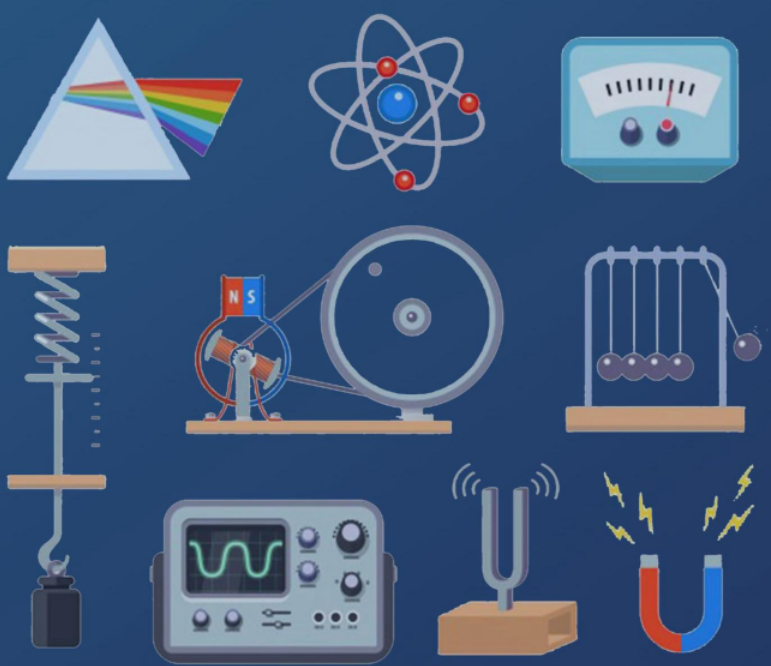
1. B **2.** B,D **3.** C **4.** B **5.** C

6. A **7.** B **8.** D **9.** C **10.** 20°C

11. 5 sec slow **12.** $200\alpha\Delta T$

PHYSICS

Thermodynamics



SHEET

eSaral.com

Contents

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3.	Exercise 1	Page - 1
4.	Exercise 1A	Page - 4
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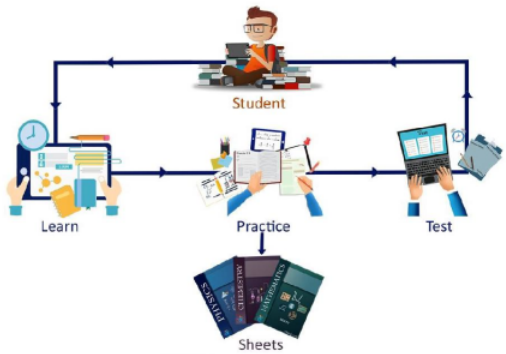
7.	Answer Key	Page - 15

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Work Done By Gas	1	17	1	1
2	First Law of Thermodynamics	2,3	1	2,3	2,3
3	Isochoric and Isobaric Process	4-10	2-4, 18,19	4	4,17
4	Isothermal Process		5,6	5-7	
5	Adiabatic Process	11,12	7,8	8-12	5,18
6	Polytropic Process and Free Expansion of Gas		9,15	13-15	6,7,22
7	Miscellaneous Practice Qs	13-16	16	16-19	8-11, 16,19
8	Carnot Engine And Second Law of Thermodynamics	17	10,12-14		20
9	Refrigerators And Heat Pumps	18	20	20,21	12,21
10	After Full Chapter	19	11	22	13-15

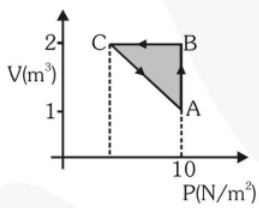
Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Work Done By Gas

Q1. An ideal gas is taken through the cycle $A \to B \to C \to A$, as shown in the figure. If the net heat supplied to the gas in the cycle is 5 J, the work done by the gas in the process $C \to A$ is :–



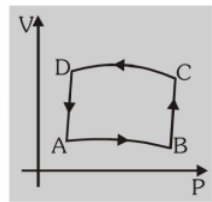
(A) –5J (B) –10J
(C) –15J (D) –20J

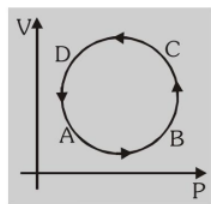
First Law of Thermodynamics

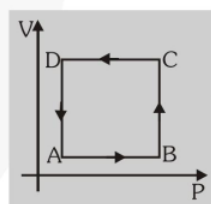
Q2. 1 kg of a gas does 20 kJ of work and receives 16 kJ of heat when it is expanded between two states. A second kind of expansion can be found between the same initial and final state which requires a heat input of 9 kJ. The work done by the gas in the second expansion is :

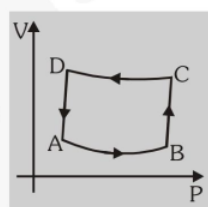
(A) 32 kJ (B) 5 kJ
(C) – 4 kJ (D) 13 kJ

Q3. In the diagrams (i) to (iv) of variation of volume with changing pressure is shown. A gas is taken along the path ABCDA. The change in internal energy of the gas will be:-

(i)


(ii)


(iii)


(iv)


(A) Positive in all cases (i) to (iv)
(B) Positive in cases (i), (ii) and (iii) but zero in case (iv)
(C) Negative in cases (i), (ii) and (iii) but zero in case (iv)
(D) Zero in all the four cases

Isochoric and Isobaric Process

Q4. C_P is always greater than C_V due to the fact that :–

(A) No work is being done on heating the gas at constant volume.
(B) When a gas absorbs heat at constant pressure its volume do not change so as to do some external work.

(C) The internal energy is a function of temperature only for an ideal gas.

(D) For the same rise of temperature, the internal energy of a gas changes by a smaller amount at constant volume than at constant pressure.

Q5. **Statement–1 :** In a process if initial volume is equal to the final volume, work done by the gas is zero.

Statement–2 : In an isochoric process work done by the gas is zero.

(A) Statement–1 is True, Statement–2 is True; Statement–2 is a correct explanation for Statement–1.

(B) Statement–1 is True, Statement–2 is True; Statement–2 is not a correct explanation for Statement–1.

(C) Statement–1 is True, Statement–2 is False.

(D) Statement–1 is False, Statement–2 is True.

Q6. If one mole of a mono-atomic gas $\left[\gamma = \frac{5}{3}\right]$ is mixed with one mole of a diatomic gas $\left[\gamma = \frac{7}{5}\right]$, the value of γ for the mixture is :-

(A) 1.4 (B) 1.5 (C) 1.53 (D) 3.07

Q7. For a gas if $\gamma = 1.4$, then atomicity, C_p and C_v of the gas are respectively :–

(A) monoatomic, $\frac{5}{2}R$, $\frac{3}{2}R$

(B) monoatomic, $\frac{7}{2}R$, $\frac{5}{2}R$

(C) diatomic, $\frac{7}{2}R$, $\frac{5}{2}R$

(D) triatomic, $\frac{7}{2}R$, $\frac{5}{2}R$

Q8. Correct relation between molar specific heat at constant pressure and constant volume :- (R universal gas constant)

(A) $C_P - C_V = r$

(B) $C_P - C_V = R$

(C) $C_P + C_V = R$

(D) $m\,C_P dt - mC_V dt = R$

Q9. For an ideal monoatomic gas, the universal gas constant R is n times the molar heat capacity at constant pressure C_p. Here n is -

(A) 0.67 (B) 1.4

(C) 0.4 (D) 1.67

Q10. If the ratio of specific heat of a gas at constant pressure to that at constant volume is γ, the change in internal energy of a mole of gas, when the volume changes from V to 2V at constant pressure P, is :-

(A) $R/(\gamma - 1)$ (B) PV

(C) $PV/(\gamma - 1)$ (D) $\gamma PV/(\gamma - 1)$

Adiabatic Process

Q11. The adiabatic Bulk modulus of a diatomic gas at atmospheric pressure is

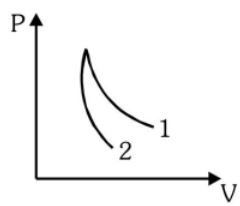
(A) 0 Nm^{-2}

(B) 1 Nm^{-2}

(C) 1.4×10^4 Nm^{-2}

(D) 1.4×10^5 Nm^{-2}

Q12. P–V plots for two gases during adiabatic processes are shown in the figure. Plots 1 and 2 should correspond respectively to :



(A) He and O_2 (B) O_2 and He

(C) He and Ar (D) O_2 and N_2

Miscellaneous Practice Qs

Q13. One mole of an ideal gas at temperature T_1 expands according to the law $\frac{P}{V^2} = a$ (constant). The work done by the gas till temperature of gas becomes T_2 is :

(A) $\frac{1}{2}R(T_2 - T_1)$ (B) $\frac{1}{3}R(T_2 - T_1)$

(C) $\frac{1}{4}R(T_2 - T_1)$ (D) $\frac{1}{5}R(T_2 - T_1)$

Q14. An ideal gas expands isothermally from a volume V_1 to V_2 and then compressed to original volume V_1 adiabatically. Initial pressure is P_1 and final pressure is P_3. The total work done is W. Then -

(A) $P_3 > P_1$, $W > 0$ (B) $P_3 < P_1$, $W < 0$

(C) $P_3 > P_1$, $W < 0$ (D) $P_3 = P_1$, $W = 0$

Q15. Starting with the same initial conditions, an ideal gas expands from volume V_1 to V_2 in three different ways, the work done by the gas W_1 if the process is purely isothermal, W_2 if purely isobaric and W_3 if purely adiabatic, then :-

(A) $W_2 > W_1 > W_3$ (B) $W_2 > W_3 > W_1$

(C) $W_1 > W_2 > W_3$ (D) $W_1 > W_3 > W_2$

Q16. n moles of an ideal gas undergo a process in which the temperature changes with volume as $T = kV^2$. The work done by the gas as the temperature changes from T_0 to $4T_0$ is-

(A) $3nRT_0$ (B) $\left(\frac{5}{2}\right)nRT_0$

(C) $\left(\frac{3}{2}\right)nRT_0$ (D)) Zero

Carnot Engine And Second Law of Thermodynamics

Q17. A Carnot engine, whose efficiency is 40%, takes in heat from a source maintained at a temperature of 500 K. It is desired to have an engine of efficiency 60%. Then, the intake temperature for the same exhaust (sink) temperature must be :

(A) 750 K

(B) 600 K

(C) Efficiency of Carnot engine cannot be made larger than 50%

(D) 1200 K

Refrigerators And Heat Pumps

Q18. An ideal refrigerator has a freezer at a temperature of –13°C. The coefficient of performance of the engine is 5. The temperature of the air (to which heat is rejected) will be :

(A) 325°C (B) 325 K

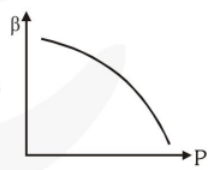
(C) 39°C (D) 320°C

After Full Chapter

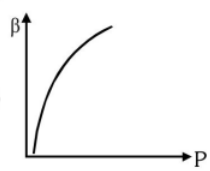
Q19. Which of the following graphs correctly represent the variation of $\beta = -\frac{dV/dP}{V}$ with P for an ideal gas at constant temperature ?

(A)

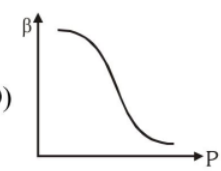
(B)



(C)



(D)



ONE OR MORE THAN ONE CORRECT TYPE

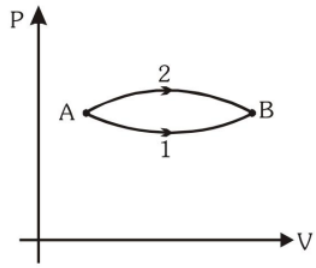
Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. In a given process of an ideal gas, dW = 0 and dQ < 0. Then for the gas :–
(A) the temperature will decrease
(B) the volume will increase
(C) the pressure will remain constant
(D) the temperature will increase

Q2. The specific heats of a gas are C_P=0.2 cal/g °C & C_V = 0.15 cal/g °C.
[Take R=2 cal/mole^{0}C]
(A) The molar mass of the gas is 40 g
(B) The molar mass of the gas cannot be determined from the data given
(C) The number of degrees of freedom of the gas molecules is 6
(D) The number of degrees of freedom of the gas molecules is 8

Q3. Statement A : $C_P - C_V = R$;
Statement B : $\frac{C_P}{C_V} = 1.67$
(A) A and B statement are true for all ideal gases.
(B) A is true for all ideal gases and B is true for only monoatomic gases
(C) A and B are true for monoatomic gases.
(D) A is true for all ideal gases and B is true for only diatomic gases

Q4. The figure shows two paths for the change of state of a gas from A to B. The ratio of molar heat capacities in path 1 and path 2 is :-

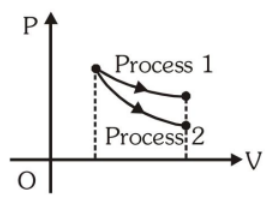


(A) > 1 (B) < 1
(C) 1 (D) Data insufficient

Q5. In the isothermal expansion of a gas :-
(A) work done on a gas is zero
(B) heat is necessarily absorbed
(C) the energy stored in the gas remains constant
(D) neither heat is supplied to the gas, nor withdrawn

Q6. The process in which the energy given to a system is completely transformed into work is :-
(A) isobaric process
(B) isometric process
(C) isothermal process
(D) adiabatic process

Q7. The indicator diagram for two process 1 and 2 carried on an ideal gas is shown in figure.
If m_1 and m_2 be the slopes $\left(\frac{dP}{dV}\right)$ for process 1 and process 2 respectively, then:–



(A) $m_1 = m_2$ (B) $m_1 > m_2$
(C) $m_1 < m_2$ (D) $m_2 C_V = m_1 C_P$

Q8. An ideal gas is heated from temperature T_1 to T_2 under various conditions. The correct statement(s) is/are :-

(A) $\Delta U = nC_V (T_2 - T_1)$ for isobaric, isochoric and adiabatic process

(B) Work is done at expense of internal energy in an adiabatic process and both have equal values

(C) $\Delta U = 0$ for an isothermal process

(D) $C = 0$ for an adiabatic process

Q9. 2 moles of a monoatomic gas are expanded to double its initial volume, through a process P/V = constant. If its initial temperature is 300 K, then which of the following is not true.

(A) $\Delta T = 900$ K (B) $\Delta Q = 3200R$

(C) $\Delta Q = 3600R$ (D) $W = 900R$

Q10. According to the second law of thermodynamics :

(A) Heat energy cannot be completely converted to work

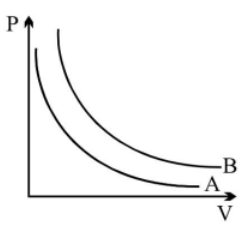
(B) Work cannot be completely converted to heat energy

(C) For all cyclic processes we have $dQ/T < 0$

(D) The reason all heat engine efficiencies are less than 100% is friction, which is unavoidable

(E) All of the above are true

Q11. Figure shows the pressure P versus volume V graphs for two different gas sample at a given temperature. M_A and M_B are masses of two samples, n_A and n_B are numbers of moles. Which of the following ***must be incorrect.***



(A) $M_A > M_B$ (B) $M_A < M_B$

(C) $n_A > n_B$ (D) $n_A < n_B$

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 12 & 14

Entropy (S) is a thermodynamic variable like pressure P, volume V and temperature T. Entropy of a thermodynamic system is a measure of disorder of molecular motion. Greater is disorder, greater is entropy. Change in entropy of a thermodynamic system is the ratio of heat supplied to absolute temperature. In an adiabatic reversible process, entropy remains constant while in any irreversible process entropy increases. In nature the processes are irreversible; therefore entropy of universe is continuously increasing.

Q12. The unit of entropy in S–I system is–

(A) cal/K

(B) joule/kg

(C) joule/K

(D) kilocal/°C

Q13. When milk is heated, its entropy :

(A) increases

(B) decreases

(C) remains unchanged

(D) may decrease or increase

Q14. After a long–long time, the energy available for work will be :

(A) as much as present value

(B) much less than present value

(C) much more than present value

(D) can not say

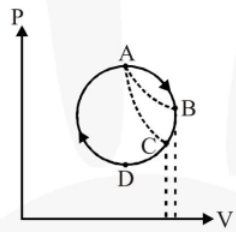
MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q15.

Column–I	Column–II
(A) Isobaric process	(p) No heat exchange
(B) Isothermal process	(q) Constant pressure
(C) Isoentropy process	(r) Constant internal energy
(D) Isochoric process	(s) Work done is zero

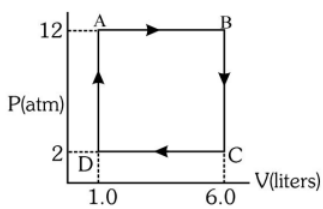
Q16. For an ideal gas a process PV diagram is a circle. An adiabatic from A passes through C. An isotherm from A passes through B. We take a part of the circular cyclic process. Comment on the sign of the quantity of column-I.



Column-I	Column-II
(A) Heat given to the gas in going from A to C along circle	(p) Positive
(B) Heat given to the gas in going from B to C along circle	(q) Negative
(C) Heat given to the gas in going from C to D along circle	(r) Zero
	(s) can't be said

SUBJECTIVE TYPE

Q17. The adjoining diagram shows a P–V graph of the thermodynamic behaviour of an ideal gas. Find out from this graph (i) Work in the processes A→ B, B→ C, C→ D and D→ A,



Q18. For a gas $\frac{R}{C_P} = 0.4$. For this gas calculate the following –

(a) atomicity and degree of freedom

(b) value of C_v and γ

(c) mean gram - molecular kinetic energy at 300 K temperature

Q19. At 8 atm pressure a monoatomic gas is expands from 2 litre to 5 litre then calculate the following

(a) Work done by the gas

(b) Increase in internal energy

(c) Amount of heat supplied

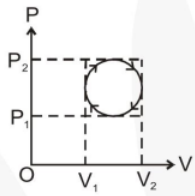
Q20. A refrigerator takes heat from water at 0°C and transfer it to room at 27°C. If 100 kg of water is converted in ice at 0°C then calculate the workdone.

(Latent heat of ice is 3.4×10^5 J/kg)

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. In a cyclic process shown on the P – V diagram the magnitude of the work done is :



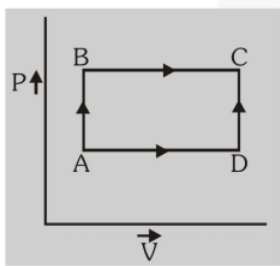
(A) $\pi\left(\frac{P_2 - P_1}{2}\right)^2$

(B) $\pi\left(\frac{V_2 - V_1}{2}\right)^2$

(C) $\frac{\pi}{4}(P_2 - P_1)(V_2 - V_1)$

(D) $\pi(P_2V_2 - P_1V_1)$

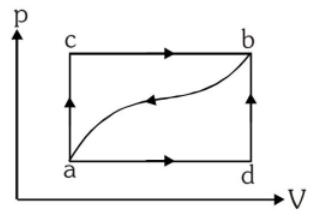
Q2. As shown in the figure, the amount of heat absorbed along the path ABC is 90J and the amount of work done by the system is 30 J. If the amount of work done along the path ADC is 20 J the amount of heat absorbed will be :-



(A) 80 J (B) 90 J

(C) 110 J (D) 120 J

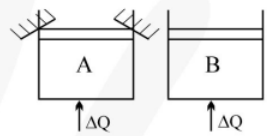
Q3. When a system is taken from state 'a' to state 'b' along the path 'acb', it is found that a quantity of heat Q = 200 J is absorbed by the system and a work W = 80J is done by it. Along the path 'adb', Q = 144J. The work done along the path 'adb' is



(A) 6J (B) 12 J

(C) 18 J (D) 24 J

Q4. Two identical vessels A & B contain equal amount of ideal monoatomic gas. The piston of A is fixed but that of B is free. Same amount of heat is absorbed by A & B. If B's internal energy increases by 100 J, then change in internal energy of A is :-



(A) 100 J (B) $\frac{500}{3}$ J

(C) 250 J (D) none of these

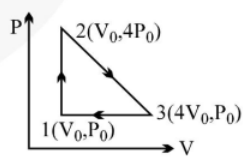
Q5. One mole of an ideal diatomic gas is taken through the cycle as shown in the figure.

$1 \rightarrow 2$: isochoric process

$2 \rightarrow 3$: straight line on P-V diagram

$3 \rightarrow 1$: isobaric process

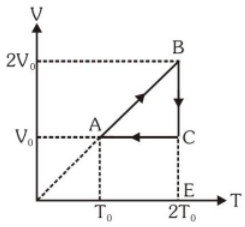
The average molecular speed of the gas in the states 1, 2 and 3 are in the ratio



(A) 1 : 2 : 2 (B) $1 : \sqrt{2} : \sqrt{2}$

(C) 1 : 1 : 1 (D) 1 : 2 : 4

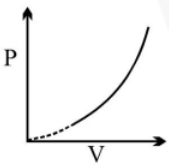
Q6. An ideal one mole monoatomic gas undergoes a cyclic process ABCA as shown in the fig. The ratio of heat absorbed during AB to the work done on the gas during BC is:–

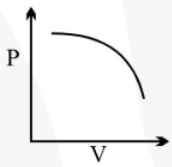


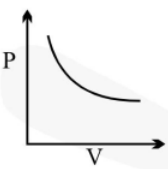
(A) $\frac{5}{2\ell n 2}$ (B) $\frac{5}{3}$

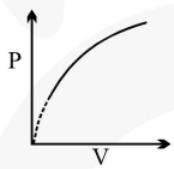
(C) $\frac{5}{4\ell n 2}$ (D) $\frac{5}{6}$

Q7. An ideal gas follows a process PT = constant. The correct graph between pressure & volume is -

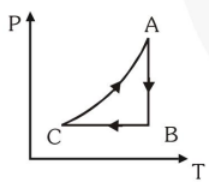
(A) 

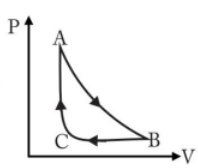
(B) 

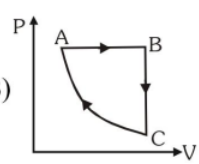
(C) 

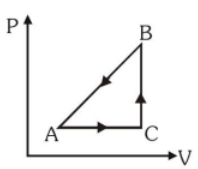
(D) 

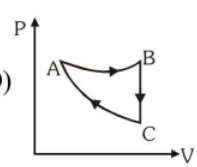
Q8. The P–T diagram for an ideal gas is shown in the figure, where AC is an adiabatic process, find the corresponding P–V diagram :–



(A) 

(B) 

(C) 

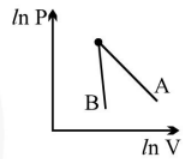
(D) 

Q9. During an adiabatic process, the pressure of a gas is found to be proportional to the cube of its absolute temperature. The ratio C_P/C_V for the gas is-

(A) 4/3 (B) 2

(C) 5/3 (D) 3/2

Q10. The figure, shows the graph of logarithmic reading of pressure and volume for two ideal gases A and B undergoing adiabatic process. From figure it can be concluded that



(A) gas B is diatomic

(B) gas A and B both are diatomic

(C) gas A is monoatomic

(D) gas B is monoatomic & gas A is diatomic

Q11. An ideal gas at 27^0C is compressed adiabatically to 8/27 of its original volume. If $\gamma = 5/3$, then the rise in temperature is:-

(A) 450 K (B) 375 K

(C) 675 K (D) 405 K

Q12. Monoatomic, diatomic and triatomic gases whose initial volume and pressure are same, are compressed till their volume becomes half the initial volume.

(A) If the compression is adiabatic then monoatomic gas will have maximum final pressure.

(B) If the compression is adiabatic then triatomic gas will have maximum final pressure.

(C) If the compression is adiabatic then their final pressure will be same.

(D) If the compression is isothermal then their final pressure will be different.

Q13. A inert gas obeys the law PV^x = constant. For what value of x, it has negative molar specific heat–

(A) $x > 1.67$ (B) $x < 1.67$

(C) $1 < x < 1.4$ (D) $1 < x < 1.67$

Q14. Four moles of hydrogen, two moles of helium and one mole of water vapour form an ideal gas mixture. What is the molar specific heat at constant pressure of mixture?

(A) $\frac{16}{7}R$ (B) $\frac{23}{7}R$

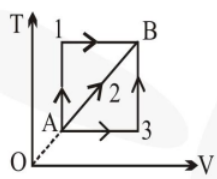
(C) $\frac{19}{7}R$ (D) $\frac{26}{7}R$

Q15. If γ be the ratio of specific heats of a perfect gas, the number of degrees of freedom of a molecule of the gas is:

(A) $\frac{25}{2}(\gamma-1)$ (B) $\frac{3\gamma-1}{2\gamma-1}$

(C) $\frac{2}{\gamma-1}$ (D) $\frac{9}{2}(\gamma-1)$

Q16. A given mass of a gas expands from a state A to the state B by three paths 1, 2 and 3 as shown in T-V indicator diagram. If W_1, W_2 and W_3 respectively be the work done by the gas along the three paths, then-



(A) $W_1 > W_2 > W_3$

(B) $W_1 < W_2 < W_3$

(C) $W_1 = W_2 = W_3$

(D) $W_1 < W_2$, $W_1 > W_3$

Q17. An ideal gas expands from volume V_1 to V_2. This may be achieved by either of the three processes: isobaric, isothermal and adiabatic. Let ΔU be the change in internal energy of the gas, Q be the quantity of heat added to the system and W be the work done by the gas . Identify which of the following statements is not true for ΔU?

(A) ΔU is least under adiabatic process.

(B) ΔU is greatest under adiabatic process.

(C) ΔU is greatest under the isobaric process.

(D) ΔU in isothermal process lies in-between the values obtained under isobaric and adiabatic processes.

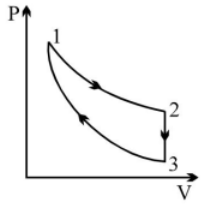
Q18. Three processes form a thermodynamic cycle as shown on P-V diagram for an ideal gas. Process $1 \rightarrow 2$ takes place at constant temperature (300K). Process $2 \rightarrow 3$ takes place at constant volume. During this process 40J of heat leaves the system. Process $3 \rightarrow 1$ is adiabatic and temperature T_3 is 275K. Work done by the gas during the process $3 \rightarrow 1$ is :-

(A) – 40J

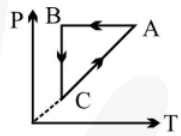
(B) – 20J

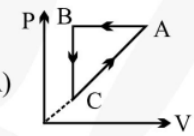
(C) +40J

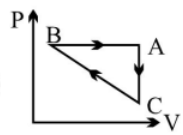
(D) +20J



Q19. A cyclic process ABCA is shown in PT diagram. When presented on PV, it would



(A)


(B)


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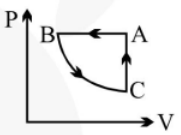
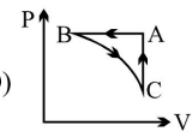


(D)


Q20. A carnot engine takes 3×10^6 cal of heat from a reservoir at 627 °C and gives it to a sink at 27 °C. The work done by the engine is-

(A) 4.2×10^6 J (B) 8.4×10^6 J

(C) 16.8×10^6 J (D) zero

Q21. A carnot engine, whose efficiency is 40%, takes heat from a source maintained at temperature of 500K. It is desired to have an engine of efficiency 60% then, the intake temperature for the same must be :

(A) 250 K (B) 750 K

(C) 350 K (D) 700 K

Q22. A reversible refrigerator operates between a low temperature reservoir at T_C and a high temperature reservoir at T_H. Its coefficient of performance is given by :

(A) $(T_H - T_C)/T_C$ (B) $T_C/(T_H - T_C)$

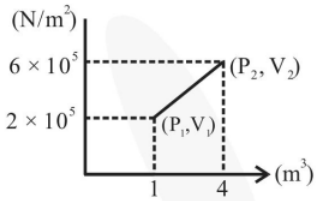
(C) $(T_H - T_C)/T_H$ (D) $T_H/(T_H - T_C)$

(E) $T_H(T_H + T_C)$

ONE OR MORE THAN ONE CORRECT TYPE

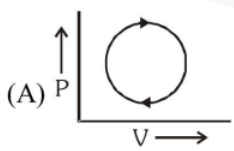
*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

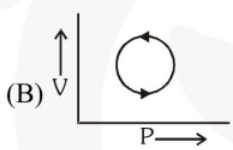
Q1. A system changes from the state (P_1, V_1) to (P_2, V_2) as shown in the figure below. What is the work done by the system :-

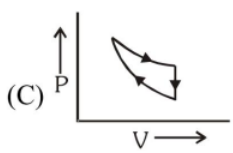


(A) 7.5×10^5 Joule (B) 7.5×10^4 erg
(C) 12×10^5 Joule (D) 6×10^5 Joule

Q2. The following are the P–V diagrams for cyclic processes for a gas. In which of these processes is heat absorbed by the gas ?

(A) 

(B) 

(C) 

(D)

Q3. During the melting of a slab of ice at 273 K at atmospheric pressure:–

(A) Positive work is done by the ice–water system on the atmosphere.

(B) Positive work is done on the ice–water system by the atmosphere.

(C) The internal energy of ice–water system increases.

(D) The internal energy of the ice–water system decreases.

Q4. A vertical cylinder with heat-conducting walls is closed at the bottom and is fitted with a smooth light piston. It contains one mole of an ideal gas. The temperature of the gas is always equal to the surrounding's temperature T_0. The piston is moved up slowly to increase the volume of the gas to η times. Which of the following is incorrect?

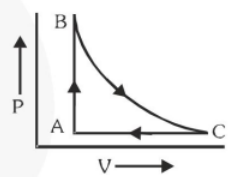
(A) Work done by the gas is $RT_0 \ln \eta$.

(B) Work done against the atmosphere is $RT_0(\eta - 1)$.

(C) There is no change in the internal energy of the gas.

(D) The final pressure of the gas is $\frac{1}{(\eta - 1)}$ times its initial pressure.

Q5. One mole of monoatomic ideal gas undergoes a cyclic process ABCA as shown in figure. Process BC is adiabatic. The temperatures at A, B and C are 300, 600 and 450K respectively. Choose the correct statement(s).



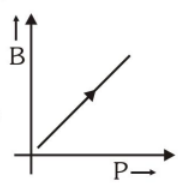
(A) In process CA change in internal energy is 225R.

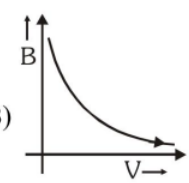
(B) In process AB change in internal energy is –150R.

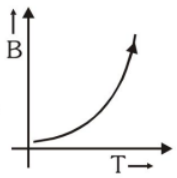
(C) In process BC change in internal energy is –225R.

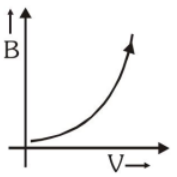
(D) Change in internal energy during the whole cyclic process is +150R.

Q6. A sample of gas follows process represented by PV^2 = constant. Bulk modulus for this process is B, then which of the following graph is correct?

(A) 

(B) 

(C) 

(D) 

Q7. An ideal gas expands in such a way that PV^2 = constant throughout the process.

(A) The graph of the process of T-V diagram is a parabola.

(B) The graph of the process of T-V diagram is a straight line.

(C) Such an expansion is possible only with heating.

(D) Such an expansion is possible only with cooling.

Q8. A gas expands such that its initial and final temperatures are equal. Also, the process followed by the gas traces a straight line on the P–V diagram :-

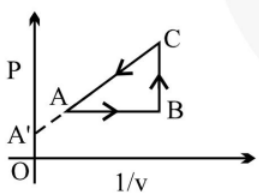
(A) The temperature of the gas remains constant throughout.

(B) The temperature of the gas first increases and then decreases.

(C) The temperature of the gas first decreases and then increases.

(D) The straight line has a negative slope.

Q9. An enclosed ideal gas is taken through a cycle as shown in the figure. Then



(A) Along AB, temperature decreases while along BC temperature increases

(B) Along AB, temperature increases while along BC the temperature decreases.

(C) Along CA work is done by the gas and the internal energy remains constant.

(D) Along CA work is done on the gas and internal energy of the gas increases.

Q10. An ideal gas can be expanded from an initial state to a certain volume through two different processes :

(i) PV^2 = constant and

(ii) $P = KV^2$ where K is a positive constant.

Then:–

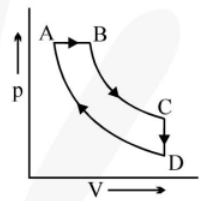
(A) Final temperature in (i) will be greater than in (ii)

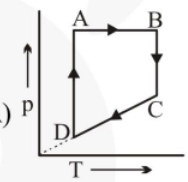
(B) Final temperature in (ii) will be greater than in (i)

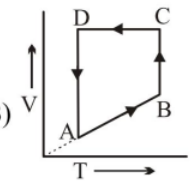
(C) Total heat given to the gas in (i) case is greater than in (ii)

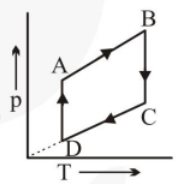
(D) Total heat given to the gas in (ii) case is greater than in (i)

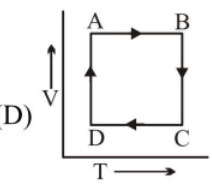
Q11. A cyclic process ABCD is shown in the p-V diagram. Which of the following curves represents the same process if BC & DA are isothermal processes



(A) 

(B) 

(C) 

(D) 

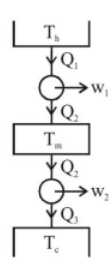
Q12. Suppose that two heat engines are connected in series, such that the heat exhaust of the first engine is used as the heat input of the second engine as shown in figure. The efficiencies of the engines are η_1 and η_2, respectively. The net efficiency of the combination is given by :

(A) $\eta_{net} = \eta_2 + (1-\eta_1)\eta_2$

(B) $\eta_{net} = \dfrac{\eta_1}{(1-\eta_1)\eta_2}$

(C) $\eta_{net} = \eta_1 + (1-\eta_1)\eta_2$

(D) $\eta_{net} = \dfrac{1-\eta_1}{(1-\eta_2)\eta_2}$

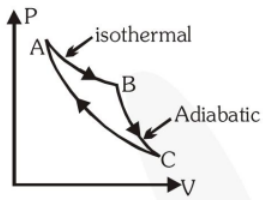


PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 13 & 15

A cyclic process for an ideal gas is shown in figure. Given $W_{AB} = +700$ J, $W_{BC} = +400$ J, $Q_{CA} = -100$J.



Q13. Find ΔU_{BC}

(A) –700 J (B) –400 J

(C) –100 J (D) 400 J

Q14. Find W_{CA}

(A) –500 J (B) 500 J

(C) 400 J (D) –400 J

Q15. The efficiency of the cycle is -

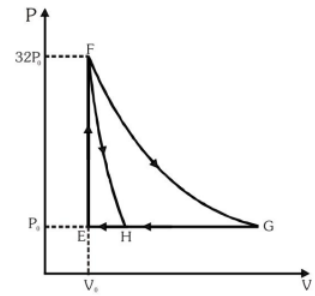
(A) 100% (B) 83.44%

(C) 85.71% (D) 81.11%

MATCHING LIST TYPE

*Each question has TWO (02) **matching lists: LIST I and LIST II**. FOUR options are given representing matching of elements from LIST I and LIST II. ONLY ONE of these four options corresponds to a correct matching For each question, choose the option corresponding to the correct matching.*

Q16. One mole of a monatomic ideal gas is taken along two cyclic processes E→F→G→E and E→F→H→E as shown in the PV diagram. The processes involved are purely isochoric, isobaric, isothermal or adiabatic.



Match the paths in List I with the magnitudes of the work done in List II and select the correct answer using the codes given below the lists.

List I	**List II**
P. G → E	1. 160 $P_0 V_0$ ln2
Q. G → H	2. 36 $P_0 V_0$
R. F → H	3. 24 $P_0 V_0$
S. F → G	4. 31 $P_0 V_0$

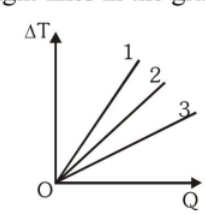
Codes :

	P	**Q**	**R**	**S**
(A)	4	3	2	1
(B)	4	3	1	2
(C)	3	1	2	4
(D)	1	3	2	4

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q17. The straight lines in the figure depict the variations in temperature ΔT as a function of the amount of heat supplied Q in different process involving the change of state of a monoatomic and a diatomic ideal gas. The initial states (P,V,T) of the two gases are the same. Match the processes as described, with the straight lines in the graph as numbered.



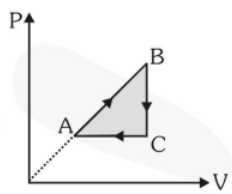
Column-I	Column-II
(A) Iosbaric process of monoatomic gas.	(p) 1
(B) Isobaric process of diatomic gas	(q) 2
(C) Isochoric process of monoatomic gas	(r) 3
(D) Isochoric process of diatomic gas	(s) x-axis (i.e. 'Q' axis)

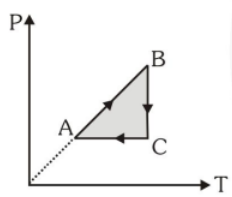
Q18. For one mole of a monoatomic gas :–

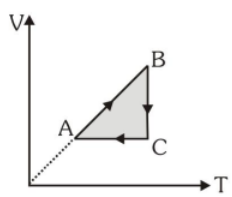
Column I	Column II
(A) Isothermal bulk modulus	(p) $-\frac{RT}{V^2}$
(B) Adiabatic bulk modulus	(q) $-\frac{5P}{3V}$
(C) Slope of P–V graph in isothermal process	(r) T/V
(D) Slope of P–V graph in adiabatic process	(s) 4T/3V
	(t) None

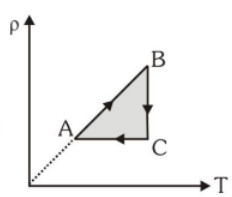
Q19. For a ideal monoatomic gas match the following graphs for constant mass in different processes (ρ = Density of gas)

Column I

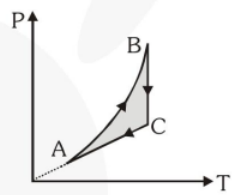
(A)


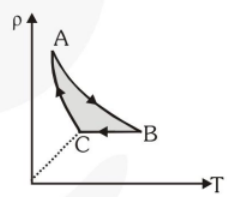
(B)


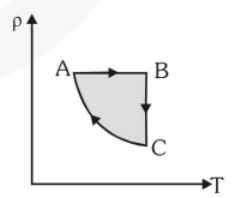
(C)


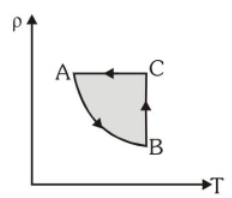
(D)


Column II

(p)


(q)


(r)


(s)


NUMERICAL TYPE

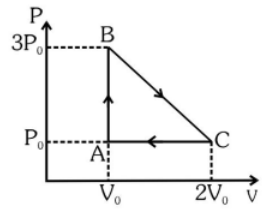
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q20. A carnot engine working between 400 K and 800 K has a work output of 1200 J per cycle. What is the amount of heat energy supplied to the engine from source per cycle?

Q21. The temperature insides & outside of refrigerator are 260 K and 315 K respectively. Assuming that the refrigerator cycle is reversible, calculate the heat delivered to surroundings for every joule of work done.

SUBJECTIVE TYPE

Q22. One mole of an ideal monoatomic gas is taken round the cyclic process ABCA as shown in fig. calculate.



(a) The work done by the gas.

(b) The heat rejected by the gas in the path CA and heat absorbed in the path AB.

(c) The net heat absorbed by the gas in the path BC.

Answer Key

Ex-1									
1	2	3	4	5	6	7	8	9	10
A	D	D	A	D	B	C	B	C	C
11	12	13	14	15	16	17	18	19	
D	B	B	C	A	C	A	C	A	

Ex-1A

1. A **2.** A,C **3.** B **4.** B **5.** B,C
6. C **7.** C,D **8.** A,B,C,D **9.** B **10.** A
11. C **12.** C **13.** A **14.** B
15. (A)→ q; (B)→ r; (C)→ p; (D)→ s
16. (A)→ p; (B)→ q; (C)→ q
17. A→ B 6000 J, B→ C is zero, C→ D –1000 J, and D→ A is Zero
18. $\frac{3}{2}R$ (monoatomic) & degree of freedom f = 3

(b) $C_v = \frac{3}{2}R$ and $\gamma = \frac{5}{3}$, (c) 450R
19. (a) 24×10^2 J, (b) 36×10^2 J, (c) 60×10^2 J
20. 3.36×10^6 J

Ex-2									
1	2	3	4	5	6	7	8	9	10
C	A	D	B	A	C	C	A	D	D
11	12	13	14	15	16	17	18	19	20
B	A	D	B	C	A	B	A	C	B
21	22								
B	B								

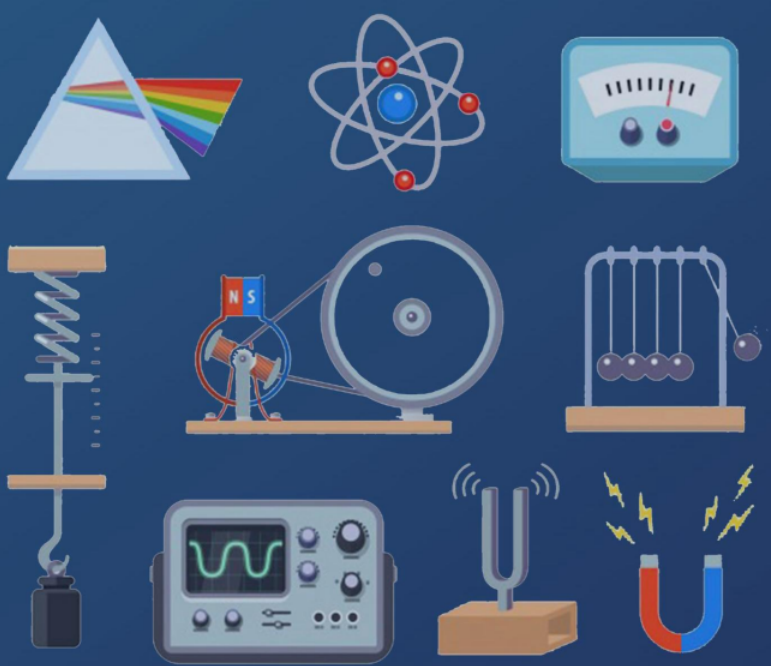
Ex-2A

1. C **2.** A,B,C **3.** B,C **4.** D **5.** C
6. A,B,C **7.** D **8.** B,D **9.** A **10.** A,C
11. A,B **12.** C **13.** B **14.** A **15.** C
16. A
17. (A)→ q; (B)→ r; (C)→ p; (D)→ q
18. (A)→ t; (B)→ t; (C)→ p; (D)→ q
19. (A)→ s; (B)→ r; (C)→ q; (D)→ p
20. 2400 joule per cycle
21. 5.7 J
22. (a) P_0V_0, (b) $\frac{5}{2}P_0V_0$, $3P_0V_0$, (c) $\frac{P_0V_0}{2}$

-: Important Notes & Formulas :-

PHYSICS

Wave on String



SHEET

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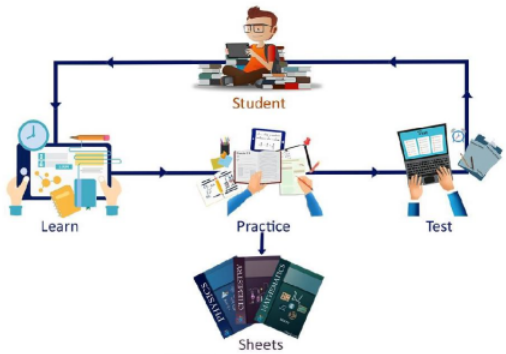
5.	Exercise 2	Page - 4
6.	Exercise 2A	Page - 8
7.	Answer Key	Page - 12

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Wave introduction				
2	Wave Function	1,2	1,2		10-12
3	Sine wave travelling on a string	3-7	3-5,11	1-4	
4	Velocity of wave on string	8,9	8	5,6	19,20
5	Power transmission of travelling wave			7,8	
6	Interference of waves			9,10	
7	Transmission of waves			11-13	13-15
8	Standing waves	10			
9	General equation of standing wave			14	1
10	Normal modes on strings	11-13	9	15-20	2-6
11	Energy in standing waves		6,7		7,16-18
12	After full Chapter		10		8,9

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Wave Function

Q1. At x=0 particle oscillate by law $y=\frac{3}{2t^2+1}$. If wave is propagating along –ve x axis with velocity 2m/s. Find equation of wave

(A) $y=\frac{3}{2\left(t-\frac{x}{2}\right)^2+1}$

(B) $y=\frac{3}{2\left(t+\frac{x}{2}\right)^2+1}$

(C) $y=\frac{3}{2\left(t-\frac{z}{2}\right)^2+1}$

(D) $y=\frac{3}{2\left(t+\frac{z}{2}\right)^2+1}$

Q2. The shape of a wave propagating in the positive x or negative x- direction is given $y=\frac{1}{\sqrt{1+x^2}}$ at t =0 and $y=\frac{1}{\sqrt{2-2x+x^2}}$ at t = 1s where x and y are in meters. The shape the wave disturbance does not change during propagation. Find the velocity of the wave.

(A) 1 m/s in positive x direction

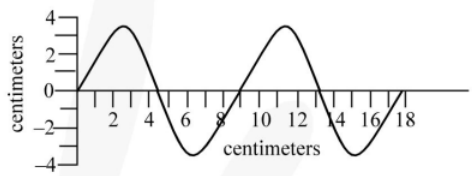
(B) 1 m/s in negative x direction

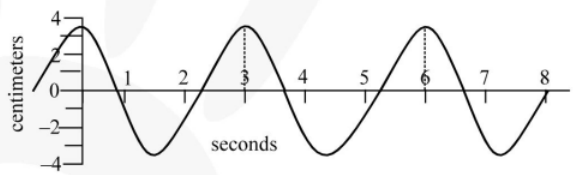
(C) $\frac{1}{2}$ m/s in positive x direction

(D) $\frac{1}{2}$ m/s in negative x direction

Sine Wave Travelling on a String

Q3. A transverse wave is travelling along a horizontal string. The first picture shows the shape of the string at an instant of time. This picture is superimposed on a coordinate system to help you make any necessary measurements. The second picture is a graph of the vertical displacement of *one* point along the string as a function of time. How far does this wave travel along the string in one second ?

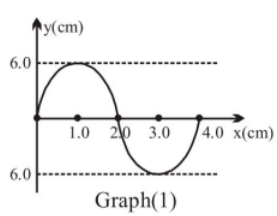




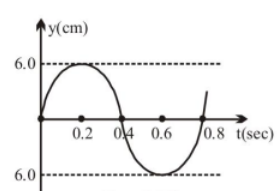
(A) 0.3 cm (B) 3.0 cm

(C) 9.0 cm (D) 27 cm

Q4. Two graphs of the same harmonic wave are shown below. The graph (1) on the left shows the displacement of wave y, as a function of position x for a given instant of time. The graph (2) on the right shows the displacement of wave as a function ot time 't' for a given position. The speed of the wave is :-



Graph(1)

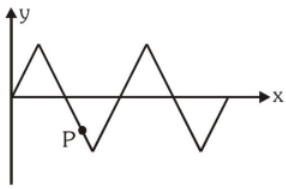


Graph(2)

(A) 5.0 cms^{-1} (B) 0.5 cms^{-1}

(C) 0.4 cms^{-1} (D) 4.0 cms^{-1}

Q5. A triangular transvers wave is propagating in the positive X-direction Velocity of P at this instant will be-



(A) Vertically upward
(B) Vertically downward
(C) At Rest
(D) Cannot be determined

Q6. The equation of a progressive wave for a wire is :

$$Y = 4\sin\left[\frac{\pi}{2}\left(8t - \frac{x}{8}\right)\right]$$

If x and y are measured in cm then velocity of wave is :
(A) 64 cm/s along - x direction
(B) 32 cm/s along - x direction
(C) 32 cm/s along + x direction
(D) 64 cm/s along + x direction

Q7. A plane wave is described by the equation

$$y = 3\cos\left(\frac{x}{4} - 10t - \frac{\pi}{2}\right).$$

The maximum velocity of the particles of the medium due to this wave is

(A) 30 (B) $\frac{3\pi}{2}$ (C) 3/4 (D) 40

Velocity of Wave on String

Q8. Transverse wave of some frequency are generated in two steel wires A and B. The diameter of A is twice of B and the tension in A is half that in B The ratio of velocities of waves in A and B is :-

(A) $1:\sqrt{2}$ (B) 1 : 2
(C) $3:2\sqrt{2}$ (D) $1:2\sqrt{2}$

Q9. The equation of a wave on a string of linear mass density 0.04 kg m^{-1} is given by

$$y = 0.02(m)\sin\left[2\pi\left(\frac{t}{0.04(s)} - \frac{x}{0.50(m)}\right)\right].$$

The tension in the string is :
(A) 6.25 N (B) 4.0 N
(C) 12.5 N (D) 0.5 N

Standing Waves

Q10. A wave is represented by the equation y = 10 sin 2π(100t – 0.02x) + 10 sin 2π(100t + 0.02x). The maximum amplitude and loop length are respectively
(A) 20 units and 30 units
(B) 20 units and 25 units
(C) 30 units and 20 units
(D) 25 units and 20 units

Normal Modes on Strings

Q11. The speed of transverse waves in a stretched string is 700 cm/s. If the string is 2 m long, the frequency with which it resonantes in fundamental mode is :
(A) (7/2) Hz (B) (7/4) Hz
(C) (14) Hz (D) (2/7) Hz

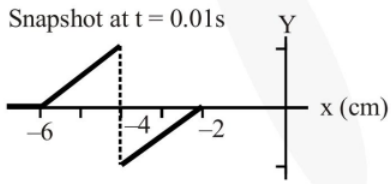
Q12. A string is rigidly tied at two ends and its equation of vibration is given by y = cos2πt sin2πx. Then minimum length of string is :-
(A) 1m (B) 1/2m
(C) 5m (D) 2π m

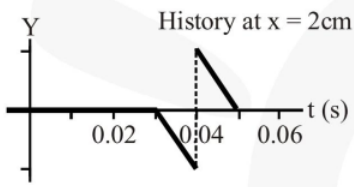
Q13. If the tension in a sonometer wire is increased by a factor of four. The fundamental frequency of vibration changes by a factor of :
(A) 4 (B) (1/4)
(C) 2 (D) (1/2)

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Figure shows a snapshot graph and a history graph for a wave pulse on a stretched string. They describe the same wave from two perspectives.





(A) The wave is travelling in positive x-direction

(B) The wave is travelling in negative x-direction

(C) The speed of the wave is 2 m/s.

(D) The peak is located at x = –6 cm at t = 0.

Q2. $Y(x,t) = 0.05 / [(4x + 2t)^2 + 5]$ represents a moving wave pulse, where x and y are in meters and t is in seconds. Then which statement(s) are **CORRECT**:

(A) Pulse is moving in – x direction

(B) Wave speed is 0.5 m/s

(C) Maximum particle displacement is 1 cm

(D) It is a symmetric pulse

Q3. The mathematical forms for three sinusoidal traveling waves are given by

Wave 1 : $y(x,t) = (2cm) \sin(3x–6t)$

Wave 2 : $y(x,t) = (3cm) \sin(4x–12t)$

Wave 3 : $y(x,t) = (4cm) \sin(5x–11t)$

where x is in meters and t is in seconds.

Of these waves :

(A) Wave 1 has the greatest wave speed and the greatest maximum transverse string speed.

(B) Wave 2 has the greatest wave speed and wave 1 has the greatest maximum transverse string speed.

(C) Wave 3 has the greatest wave speed and the greatest maximum transverse string speed.

(D) Wave 2 has the greatest wave speed and wave 3 has the greatest maximum transverse string speed.

Q4. A transverse wave travelling on a taut string is represented by $y = 0.01 \sin2\pi (10 t – x)$, y and x are in meters and t in seconds. Then:-

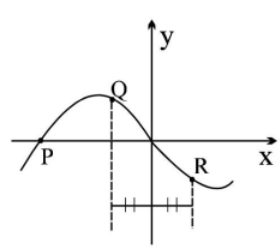
(A) The speed of the wave is 10 m/s.

(B) Closest points on the string which differ in phase by 60° are (1/6) m apart.

(C) Maximum particle velocity is $\pi/4$ m/s.

(D) The phase of a certain point on the string changes by 120° in (1/20) seconds.

Q5. At a certain moment, the photograph of a string on which a harmonic wave is travelling to the right is shown. Then, which of the following is true regarding the velocities of the points P, Q and R on the string.



(A) v_P is upwards
(B) $v_Q = -v_R$
(C) $|v_P| > |v_Q| = |v_R|$
(D) $v_Q = v_R$

Q6. A standing wave of time period T is set up in a string clamped between two rigid supports. At t = 0 antinode is at its maximum displacement 2A.
(A) The energy density of a node is equal to energy density of an antinode for the first time at t = T/4.
(B) The energy density of node and antinode becomes equal after T/2 second.
(C) The displacement of the particle at antinode at $t = \frac{T}{8}$ is $\sqrt{2}A$.
(D) The displacement of the particle at node is zero.

Q7. A clamped string is oscillating in nth harmonic, then :-
(A) Total energy of oscillations will be proportional to n^2 times that of fundamental frequency
(B) Total energy of oscillations will be proportional to $(n-1)^2$ times that of fundamental frequency
(C) Average kinetic energy of the string over a complete oscillations is half of that of the total energy of the string.
(D) None of these

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q8. A wave moves with speed 300 ms^{-1} on a wire which is under a tension of 500 N. Find how much the tension must be changed to increase the speed to 360 ms^{-1}.

Q9. A sonometer wire emits a fundamental note of frequency 150 Hz. Calculate the frequency of the note emitted when the tension is changed in the ratio of 9 : 16 and length in the ratio of 1 : 2.

Q10. A wave has a speed of 300 m/sec and frequency 500 Hz. The phase difference between two adjacent points is π/3 radian. What will be the path difference between them in cm?

SUBJECTIVE TYPE

Q11. The displacement produced by a simple harmonic wave is $y = \frac{10}{\pi}\sin\left(200\pi t - \frac{\pi x}{17}\right)$. Then find the time period and maximum velocity of the particle.
(x → m, y → cm, t → sec.)

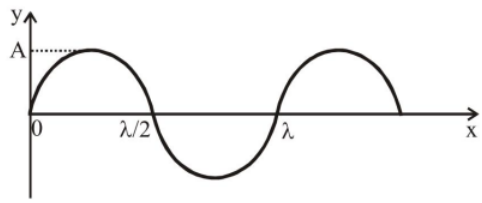
Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Here given snap shot of a progressive wave at t = 0 with time period = T. Then the equation of the wave if wave is going in +ve x-direction and if wave is going in –ve x-direction will be respectively.

$\left(\text{Here, } T = \frac{2\pi}{\omega}\right)$



(A) $y = A\sin(kx + \omega t),\ y = A\sin(kx - \omega t)$

(B) $y = A\cos(kx + \omega t),\ y = A\cos(kx - \omega t)$

(C) $y = A\sin(\omega t - kx),\ y = A\sin(\omega t + kx)$

(D) $y = A\sin(kx - \omega t),\ y = A\sin(kx + \omega t)$

Q2. A sinusoidal wave travelling in the positive direction of x on a stretched string has amplitude 2.0 cm, wavelength 1 m and wave velocity 5.0 m/s. At x = 0 and t =0, it is given that displacement y = 0 and $\frac{\partial y}{\partial t} < 0$. Express the wave function correctly in the form y = f(x, t) :-

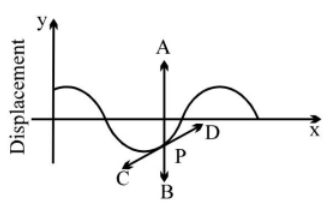
(A) $y = (0.02\text{ m})\sin 2\pi(x - 5t)$

(B) $y = (0.02\text{ cm})\cos 2\pi(x - 5t)$

(C) $y = (0.02\text{ m})\sin 2\pi\left(x - 5t + \frac{1}{4}\right)$

(D) $y = (0.02\text{ cm})\cos 2\pi\left(x - 5t + \frac{1}{4}\right)$

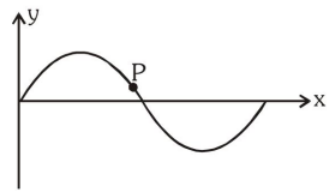
Q3. The figure below shows a snap photograph of a simple harmonic progressive wave, progressing in the negative X-axis, at a given instant. The direction of the velocity of the particle at the stage P on the figure is best represented by the arrow.



(A) $\vec{PA}$ (B) $\vec{PB}$

(C) $\vec{PC}$ (D) $\vec{PD}$

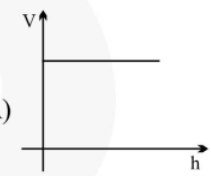
Q4. A transverse sinusoidal wave moves along a string in the positive x-direction at a speed of 10 cm/s. The wavelength of the wave is 0.5 m and its amplitude is 10 cm. At a particular time t, the snap shot of the wave is shown in figure. The velocity of P when its displacement is 5 cm is :

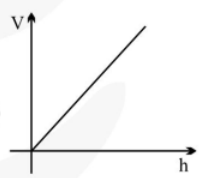


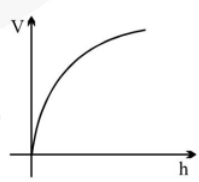
(A) $\frac{\sqrt{3}\pi}{50}\hat{i}$ m/s (B) $-\frac{\sqrt{3}\pi}{50}\hat{j}$ m/s

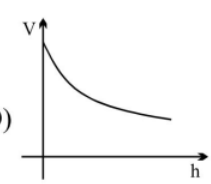
(C) $\frac{\sqrt{3}\pi}{50}\hat{j}$ m/s (D) $-\frac{\sqrt{3}\pi}{50}\hat{i}$ m/s

Q5. A uniform rope having some mass hanges vertically from a rigid support. A transverse wave pulse is produced at the lower end. The speed (v) of the wave pulse varies with height (h) from the lower end as:

(A)


(B)


(C)


(D)


Q6. The extension in a string, obeying Hookes' law, is x. The speed of the wave in the stretched string is v. If the extension in the string is increased to 1.5 x, the speed of the wave in the string will be

(A) $1.22v$ (B) $0.61v$

(C) $1.50\ v$ (D) $0.75v$

Q7. The average power transmitted by a progressive wave in term of standard notations is :-

(A) $4\pi^2 A^2 \mu^{1/2} T^{-1/2} f^2$

(B) $2\pi^2 A^2 \mu^{1/2} T^{1/2} f^2$

(C) $2\pi^2 A^2 \mu\ T^{1/2} f^2$

(D) None

Q8. The prong of a electrically operated tuning fork is connected to a long string of $\mu = 1$ kg/m and tension 25 N. The maximum velocity of the prong is 1 cm/s, then the average power needed to drive the prong is:

(A) 5×10^{-4} W (B) 2.5×10^{-4} W

(C) 1×10^{-4} W (D) 10^{-3} W

Q9. Five waveforms moving with equal speeds on the x-axis

$y_1 = 8 \sin(\omega t + kx)$;

$y_2 = 6 \sin(\omega t + \frac{\pi}{2} + kx)$;

$y_3 = 4 \sin(\omega t + \pi + kx)$;

$y_4 = 2 \sin(\omega t + \frac{3\pi}{2} + kx)$;

$y_5 = 4\sqrt{2} \sin(\omega t - kx + \frac{\pi}{4})$

are superimposed on each other. The resulting wave is :

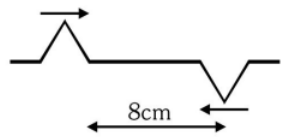
(A) $8\sqrt{2} \cos kx \sin(\omega t + \frac{\pi}{4})$

(B) $8\sqrt{2} \sin(\omega t - kx + \frac{\pi}{4})$

(C) $8\sqrt{2} \sin kx \cos(\omega t + \frac{\pi}{4})$

(D) $8 \sin(\omega t + kx)$

Q10. Two pulses in a stretched string, whose centres are initially 8 cm apart, are moving towards each other as shown in the figure. The speed of each pulse is 2 cm/s. After 2 s the total energy of the pulses will be :-



(A) Zero

(B) Purely kinetic

(C) Purely potential

(D) Partialy kinetic and partialy potential

Q11. A wave of frequency 100 Hz travels along a string towards its fixed end when this wave travels back, after reflection a node is formed at a distance of 10 cm from the fixed end. The speed of the wave (incident and reflected) is :

(A) 5 m/s (B) 10 m/s

(C) 20 m/s (D) 40 m/s

Q12. The equation of a plane progressive wave is $y = 0.02 \sin 8\pi \left[t - \frac{x}{20}\right]$. When it is reflected at a rarer medium (medium with higher velocity) at $x = 0$, its amplitude becomes 75% of its previous value. The equation of the reflected wave is :-

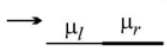
(A) $y = 0.02 \sin 8\pi \left[t - \frac{x}{20}\right]$

(B) $y = 0.02 \sin 8\pi \left[t + \frac{x}{20}\right]$

(C) $y = +0.015 \sin 8\pi \left[t + \frac{x}{20}\right]$

(D) $y = -0.015 \sin 8\pi \left[t + \frac{x}{20}\right]$

Q13. A string consists of two parts attached at x = 0. The right part of the string (x > 0) has mass μ_r per unit length and the left part of the string (x < 0) has mass μ_l per unit length. The string tension is T. If a wave of unit amplitude travels along the left part of the string, as shown in the figure, what is the amplitude of the wave that is transmitted to the right part of the string ?



(A) 1 (B) $\frac{2}{1+\sqrt{\mu_l/\mu_r}}$

(C) $\frac{2\sqrt{\mu_l/\mu_r}}{1+\sqrt{\mu_l/\mu_r}}$ (D) $\frac{\sqrt{\mu_l/\mu_r}-1}{\sqrt{\mu_l/\mu_r}+1}$

Q14. The shape of a string on which standing waves are produced at t = 0 is shown here. The suitable equation of standing wave can be :

(A) y = A sin kx cos ωt

(B) y = A sin kx sin ωt

(C) y = A cos kx sin ωt

(D) y = A cos kx cos ωt

Q15. A steel wire of length 1m, mass 0.1 kg and uniform cross sectional area 10^{-6} m^2 is rigidly fixed at both ends. The temp difference of wire is 20°C. If the transverse waves are set up by plucking the string in the middle, calcutate freq. of fundamental mode of vibration.

(Y = $2x10^{11}$ N/m^2, α = $1.21x10^{-5}$ /°C)

(A) 11 Hz (B) 20 Hz

(C) 22 Hz (D) 15Hz

Q16. A vibrator makes 150 cm of a string to vibrate in 6 loops in the longitudinal arrangement when it is stretched by 150 N. The entire length of the string is then weighed and is found to weigh 400 mg. Then:-

(A) Frequency of the vibrator is 3 kHz.

(B) Frequency of the vibrator is 1.5 kHz.

(C) Distance between two nodes is 25 cm.

(D) Distance between two nodes is 33 cm.

Q17. A sonometer wire resonates with a given tuning fork forming standing waves with five antinodes between the two bridges when a mass of 9kg is suspended from the wire. When this mass is replaced by mass M, the wire resonates with the same tuning fork forming three antinodes for the same position of the bridges. Then find the value of square root of M.

(A) 5 (B) 10

(C) 25 (D) None

Q18. A string of length 3L is fixed at both ends. It resonates with a tuning fork in third harmonic with amplitude at antinode equal to A_0. At time t = 0, a string element at position of antinode is at half its positive amplitude and moving towards mean position. Displacement of a string element at L/2 is given by :-

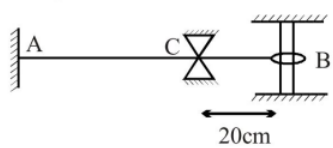
(A) $\frac{A_0}{2}\sin\left(\omega t+\frac{11\pi}{6}\right)$

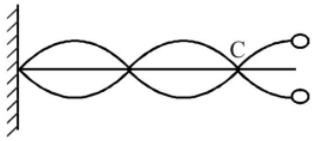
(B) $\frac{\sqrt{3}A_0}{2}\sin\left(\omega t+\frac{5\pi}{6}\right)$

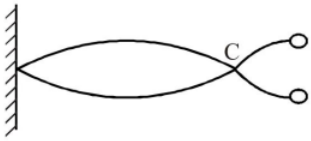
(C) $A_0\sin\left(\omega t+\frac{5\pi}{6}\right)$

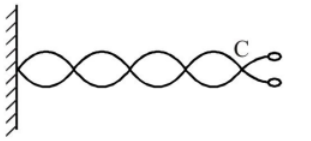
(D) $\frac{A_0}{2}\sin\left(\omega t+\frac{5\pi}{6}\right)$

Q19. A 1m long wire having tension T is fixed at A and free at B. The point C, 20 cm from B is constrained to be stationary. What is shape of string for fundamental mode ?



(A) 

(B) 

(C) 

(D)

Q20. Two vibrating strings of the same material but of lengths L and 2L have radii 2r and r respectively. They are stretched under the same tension. Both the strings vibrate in their fundamental modes, the one of length L with frequency f_1 and the other with frequency f_2. The ratio $\frac{f_1}{f_2}$ is given by :-

(A) 2 (B) 4
(C) 8 (D) 1

Exercise - 2A *Brain Booster*

ONE OR MORE THAN ONE CORRECT TYPE

Q1. The vibration of a string fixed at both ends are described by $Y= 2 \sin(\pi x) \sin(100\pi t)$ [where Y is in mm, x is in cm and t in second] then

(A) Maximum displacement of the particle at x = 1/6 cm would be 1 mm.

(B) Velocity of the particle at x = 1/6 cm at time t = 1/600 sec will be 157 $\sqrt{3}$ mm/s

(C) If the length of the string be 10 cm, number of loop in it would be 5

(D) None of these

Q2. The tension in a stretched string fixed at both ends is changed by 2%, the fundamental frequency is found to get changed by 15 Hz. Select the correct statement(s)

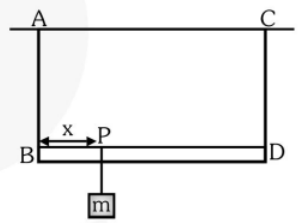
(A) Wavelength of the string of fundamental frequency does not change.

(B) Velocity of propagation of wave changes by 2%

(C) Velocity of propagation of wave changes by 1%

(D) Original frequency is 1500 Hz.

Q3. A massless rod BD is suspended by two identical massless strings AB and CD of equal lengths. A block of mass m is suspended at point P such that BP is equal to x, if the fundamental frequency of the left wire is twice the fundamental frequency of right wire, then the value of x is :-



(A) $\frac{\ell}{5}$ (B) $\frac{\ell}{4}$
(C) $\frac{4\ell}{5}$ (D) $\frac{3\ell}{4}$

Q4. Figure, shows a stationary wave between two fixed points P and Q.

Which point (s) of 1, 2 and 3 are in phase with the point X ?

(A) 1, 2 and 3 (B) 1 and 2 only
(C) 2 and 3 only (D) 3 only

Q5. An string has resonant frequencies given by 1001 Hz and 2639 Hz.

(A) If the string is fixed at one end only, 910 Hz can be a resonance frequency.

(B) If the string is fixed at one end only, 1911 Hz can be a resonance frequency.

(C) If the string is fixed at both the ends, 364 Hz can be one of the resonant frequency.

(D) 1001 Hz is definitely not the fundamental frequency of the string.

Q6. A narrow steel rod of length 'L' is rigidly clamped at its mid-point and transverse standing waves of frequency 'f' are set up in it. The speed of transverse waves in the rod is 'c'. Then :-

(A) The free ends of the rod must be Antinodes

(B) The fundamental frequency 'f' of the rod is c/(L)

(C) The second overtone frequency of the rod is 5c/(2L)

(D) 'f' can be any integral multiple of the fundamental frequency

Q7. The ends of a stretched wire of length L are fixed at x=0 and x = L. In one experiment the displacement of the wire is $y_1 = A\sin\left(\frac{\pi x}{L}\right)\sin\omega t$ and energy is E_1 and in other experiment its displacement is $y_2 = A\sin\left(\frac{2\pi x}{L}\right)\sin 2\omega t$ and energy is E_2.

Then :-

(A) $E_2 = E_1$ (B) $E_2 = 2E_1$

(C) $E_2 = 4E_1$ (D) $E_2 = 16E_1$

Q8. A plane transverse wave is propagating in a direction making an angle of 30° with positive x-axis in the x-y plane. Find phase difference between points (0, 0, 0) and (1, 1, 1). Wavelength of the wave is 1m :-

(A) 2π rad (B) $\left(\sqrt{3}+1\right)\pi$ rad

(C) $\left(\sqrt{2}+1\right)\pi$ rad (D) None

Q9. Consider a hypothetical wave pulse (at time t =0) given by the following (y, x in meter)

$y = 0, x < 0$

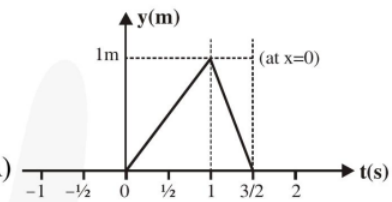
$y = x/2, 2 > x \geq 0$

$y = 3 - x, 3 \geq x \geq 2$

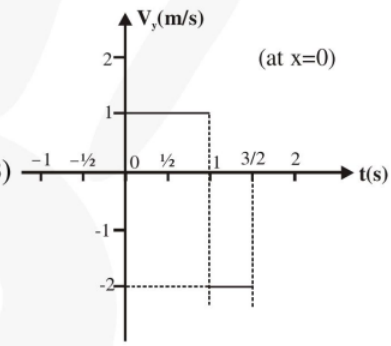
$y = 0, x > 3$

The pulse travels leftwards (negative x direction) at speed v = 2 m/s. Which of the following plots are correct? [V_y is the velocity of particle]

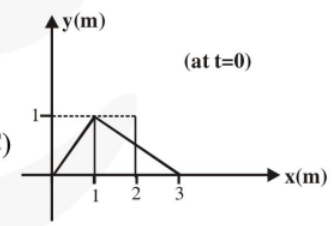
(A)



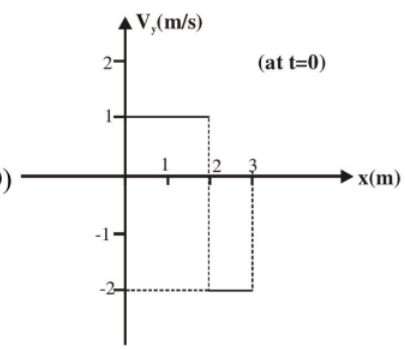
(B)



(C)



(D)



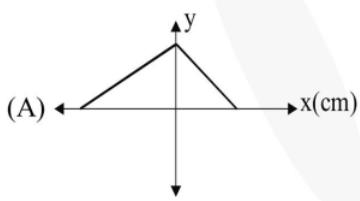
PARAGRAPH TYPE

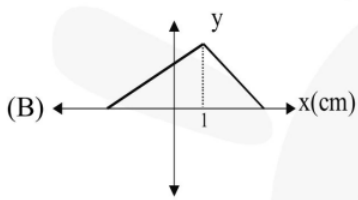
Paragraph for Question Nos. 10 to 12

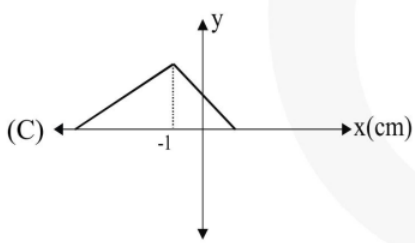
At a time t =0 a pulse moving in the +ve x-direction with velocity v in the shape given by the function

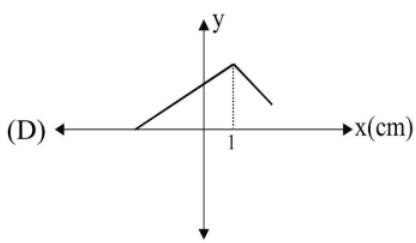
between with $y=\begin{cases}\frac{x}{4}+1 & -4<x<0\\ -x+1 & 0<x<1\\ 0 & otherwise\end{cases}$, where x and y are in cm.

Q10. If velocity is 10 m/s, which of the graphs shows the shape and position of the string at a time t = 1 millisec.

(A)


(B)


(C)


(D)


Q11. The wave equation that explicitly gives the displacement of any point at any time is :

(A) $y=\begin{cases}\frac{1}{4}(x-Vt)+1 & -4<(x-Vt)<0\\ -(x-Vt)+1 & 0<(x-Vt)<1\\ 0 & otherwise\end{cases}$

(B) $y=\begin{cases}\frac{1}{4}(x+Vt)+1 & -4<(x+Vt)<0\\ -(x+Vt)+1 & 0<(x+Vt)<1\\ 0 & otherwise\end{cases}$

(C) $y=\begin{cases}-\frac{1}{4}(x+Vt)+1 & -4<(x+Vt)<0\\ (x+Vt)+1 & 0<(x+Vt)<1\\ 0 & otherwise\end{cases}$

(D) $y=\begin{cases}-\frac{1}{4}(x-Vt)+1 & -4<(x-Vt)<0\\ (x-Vt)+1 & 0<(x-Vt)<1\\ 0 & otherwise\end{cases}$

Q12. Velocity of a point at x = 20 m as a function of time is given as

(A) $v=\begin{cases}\frac{1}{4}\,m/s & 1.999<t<2\ s\\ -1\ m/s & 2<t<2.004\ s\\ 0 & otherwise\end{cases}$

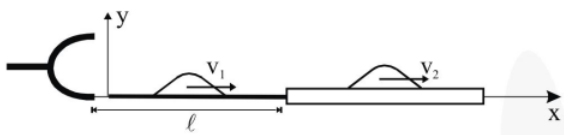
(B) $v=\begin{cases}1m/s & 1.999<t<2\ s\\ -\frac{1}{4}\ m/s & 2<t<2.004\ s\\ 0 & otherwise\end{cases}$

(C) $v=\begin{cases}10m/s & 1.999<t<2\ s\\ -\frac{5}{2}\ m/s & 2<t<2.004\ s\\ 0 & otherwise\end{cases}$

(D) $v=\begin{cases}\frac{5}{2}\,m/s & 1.999<t<2\ s\\ -10\ m/s & 2<t<2.004\ s\\ 0 & otherwise\end{cases}$

Paragraph for Question Nos. 13 to 15

A harmonic oscillator at x = 0, oscillates with a frequency $\frac{\omega}{2\pi}$ and amplitude a. It is generating waves at end of a thin string in which velocity of wave is v_1 and which is connected to another heavier string in which velocity of wave is v_2 as shown, length of first string is ℓ.



Q13. If harmonic oscillator oscillates by an equation y = a sinωt. The equation of incident wave in first string is :-

(A) $y = a\sin\omega\left(t - \frac{x}{v_1}\right)$

(B) $y = a\sin\omega\left(t + \frac{x}{v_1}\right)$

(C) $y = a\sin\left[\omega\left(t - \frac{x}{v_1}\right) + \pi\right]$

(D) $y = a\sin\left[\omega\left(t + \frac{x}{v_1}\right) + \pi\right]$

Q14. Equation of transmitted wave in second string if its amplitude is a_t is :-

(A) $y = a_t\sin\omega\left(t - \frac{x}{v_2}\right)$

(B) $y = a_t\sin\omega\left(t - \frac{\ell}{v_1}\right)$

(C) $y = a_t\sin\omega\left(t - \frac{\ell}{v_1} - \frac{x-\ell}{v_2}\right)$

(D) $y = a_t\sin\omega\left(t - \frac{x}{v_2}\right)$

Q15. Equation of reflected wave, if it is reflecting at the joint and amplitude of reflected wave is a_R.

(A) $y = a_R\sin\omega\left(t - \frac{x}{v_2}\right)$

(B) $y = a_R\sin\left[\omega\left(t - \frac{\ell}{v_1} - \frac{\ell - x}{v_1}\right) + \pi\right]$

(C) $y = a_R\sin\left[\omega\left(t + \frac{x}{v_1}\right) + \pi\right]$

(D) $y = a_R\sin\left[\omega\left(t + \frac{2\ell + x}{v_1}\right) + \pi\right]$

Paragraph for Question Nos. 16 to 18

A wave represented by equation y = 2(mm) sin $[4\pi(\text{sec}^{-1})t - 2\pi(\text{m}^{-1})x]$ is superimposed with another wave y = 2 (mm) sin $[4\pi(\text{sec}^{-1})t + 2\pi(\text{m}^{-1})x + \pi/3]$ on a tight string.

Q16. Phase difference between two particles which are located at $x_1 = 1/7$ and $x_2 = 5/12$ is

(A) 0 (B) $\frac{5\pi}{6}$

(C) π (D) $\frac{5\pi}{3}$

Q17. Which of the following is not a location of antinode?

(A) $\frac{2}{3}$ (B) $\frac{11}{12}$

(C) $\frac{5}{12}$ (D) $\frac{17}{12}$

Q18. The location having maximum potential energy is :

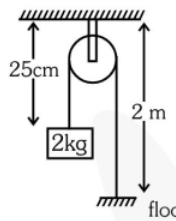
(A) 1/7 (B) 1/6

(C) 5/12 (D) 23/12

NUMERICAL TYPE

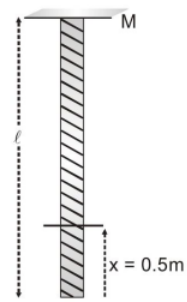
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q19. In the given figure the string has mass 4.5g. Find the time taken by a transverse pulse produced at the floor to reach the pulley. ($g = 10\ ms^{-2}$).



SUBJECTIVE TYPE

Q20. A uniform rope of mass 0.1 kg and length 2.45 m hangs from a ceiliing as shown in diagram.



(a) Find speed of transverse wave in the rope at a point 0.5 m distance from the lower end.

(b) Calculate time taken by a transverse wave to travel the full length of rope.

Answer Key

Ex-1

1	2	3	4	5	6	7	8	9	10
B	A	B	A	A	D	A	D	A	B
11	12	13							
B	B	C							

Ex-1A

1. A,C,D **2.** A,B,C,D **3.** D **4.** A,B **5.** C,D
6. C,D **7.** A,C **8.** 220 N **9.** 100 Hz **10.** 10 cm
11. $\frac{1}{100}$ s, 20m/s

Ex-2

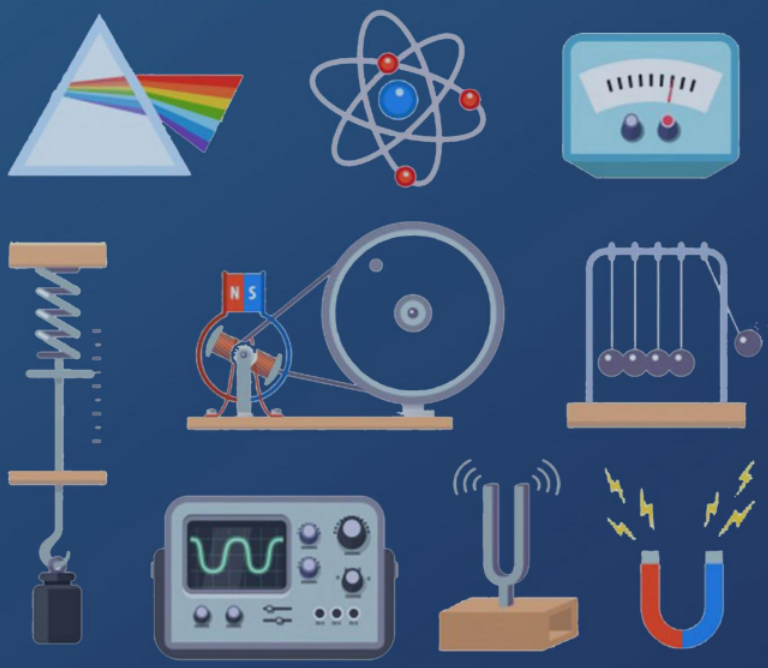
1	2	3	4	5	6	7	8	9	10
D	A	A	C	C	A	B	B	A	B
11	12	13	14	15	16	17	18	19	20
C	C	C	A	A	C	A	C	A	D

Ex-2A

1. A,B **2.** A,C **3.** A **4.** C **5.** B,C,D
6. A,C **7.** C **8.** B **9.** A,B,D **10.** B
11. A **12.** C **13.** A **14.** C **15.** B
16. C **17.** A **18.** B **19.** 0.02 s
20. (a) 2.21 m/sec , (b) 1 sec.

PHYSICS

Wave Optics



SHEET

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5.	Exercise 2	Page - 6
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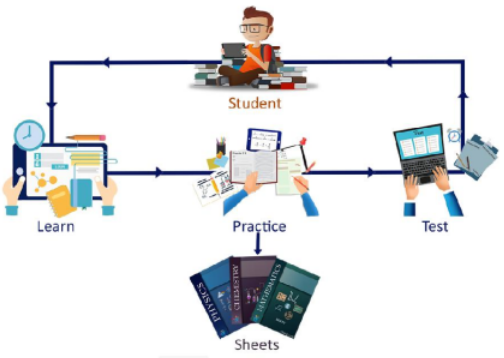
7.	Answer Key	Page - 14

Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Wave particle duality	1			
2	Wave recape				
3	Huygen's principle				1
4	Interference of waves	2-7	1	1,2	
5	YDSE	8-13	2,3,5-7, 11,12	3-9	2-7
6	Variation in intensity	14,15		10	8
7	Shape of fringes				
8	YDSE with white light	16	4	11	
9	Variation in ydse			12,13	9
10	Optical path	17-23	8-10	14-19	10-12
11	Diffraction	24-26		20,21	
12	Polarisation	27-30		23,23	
13	After Full Chapter				13-24

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Wave particle duality

Q1. Through which character we can distinguish the light waves from sound waves :

(A) Interference (B) Refraction

(C) Polarisation (D) Reflection

Interference of waves

Q2. The phase difference corresponding to path difference of x is :

(A) $\frac{2\pi x}{\lambda}$ (B) $\frac{2\pi\lambda}{x}$

(C) $\frac{\pi x}{\lambda}$ (D) $\frac{\pi\lambda}{x}$

Q3. If intensity of each of the two waves is I and they are having phase difference of 120°, when the waves are superposed, then the resultant intensity will be :

(A) I (B) 2I

(C) I/2 (D) 4I

Q4. Two wave are represented by the equations $y_1 = a \sin \omega t$ and $y_2 = a \cos \omega t$. The first wave :-

(A) leads the second by π

(B) lags the seconds by π

(C) leads the second by $\frac{\pi}{2}$

(D) lags the seconds by $\frac{\pi}{2}$

Q5. The resultant amplitude of a vibrating particle by the superposition of the two waves $y_1 = a\sin\left[\omega t + \frac{\pi}{3}\right]$ and $y_2 = a \sin \omega t$ is :-

(A) a (B) $\sqrt{2}$ a

(C) 2a (D) $\sqrt{3}$ a

Q6. Phenomenon of interference is not observed by two sodium lamps of same power. It is because both waves have :-

(A) not constant phase difference

(B) zero phase difference

(C) different intensity

(D) different frequencies

Q7. Two coherent sources of intensities I_1 and I_2 produce an interference pattern. The maximum intensity in the intrference pattern will be :-

(A) $I_1 + I_2$ (B) $I_1^2 + I_2^2$

(C) $(I_1 + I_2)^2$ (D) $(\sqrt{I_1} + \sqrt{I_2})^2$

YDSE

Q8. In Young's experiment, if X_{mr} and X_{mv} denotes the distances of mth red and violet fringe from the central fringe. Then :

(A) $X_{mr} > X_{mv}$ (B) $X_{mr} < X_{mv}$

(C) $X_{mr} = X_{mv}$ (D) $X_{mr} + X_{mv} = 0$

Q9. In Young's double slit experiment, wave-length of light is 6000Å. Then the phase difference between the light waves reaching the third bright fringe from the central fringe will be :

(A) zero (B) 2π

(C) 4π (D) 6π

Q10. If in a Young's double slit experiment, width between the slits is 3 cm, the separation between slits and screen is 7 cm and wavelength of light is 1000 Å, then fringe width will be :

(A) 2×10^{-5} m. (B) 2×10^{-9} m

(C) 0.2×10^{-6} m (D) 2.3×10^{-7} m

Q11. Young's experiment establishes that :-

(A) light consists of waves

(B) light consists of particles

(C) light consists of neither particles nor waves

(D) light consists of both particles and waves

Q12. In YDSE experiment, when two light rays make third minima, then they have :-

(A) phase difference of 3π

(B) phase difference of $\frac{5\pi}{2}$

(C) path difference of 3λ

(D) path difference of $\frac{5\lambda}{2}$

Q13. In an interference pattern of two waves fringe width is β . If the frequency of source is doubled then fringe width will become :-

(A) $\frac{1}{2}\beta$ (B) β (C) 2β (D) $\frac{3}{2}\beta$

Variation in intensity

Q14. If ratio of amplitude of two interferring source is 3 : 5. Then ratio of intensity of maxima and minima in interference pattern will be :

(A) 25 : 16 (B) 5 : 3

(C) 16 : 1 (D) 25 : 9

Q15. In the young's double slit experiment the intensity of central maxima is observed to be I_0. If one of the slits is covered, then intensity at the central maxima will become :-

(A) $\frac{I_0}{2}$ (B) $\frac{I_0}{\sqrt{2}}$ (C) $\frac{I_0}{4}$ (D) I_0

YDSE with white light

Q16. In Young's double slit experiment, if monochromatic light is replaced by white light :-

(A) all bright fringes become white

(B) all bright fringes have coloures between violet and red

(C) only the central fringe is white, all other fringes are coloured

(D) no fringes are observed

Optical path

Q17. In Young's experiment, monochromatic light through a single slit S is used to illuminate the two slits S_1 and S_2. Interference fringes are obtained on a screen. The fringe width is found to be w. Now a thin sheet of mica (thickness t and refractive index μ) is placed near and in front of one of the two slits. Now the fringe width is found to be w′, then :

(A) $w' = w/\mu$ (B) $w' = w\mu$

(C) $w' = (\mu - 1)\,tw$ (D) $w' = w$

Q18. If a transparent medium of refractive index $\mu = 1.5$ and thickness $t = 2.5 \times 10^{-5}$ m is inserted in front of the slits of Young's Double slit experiment, how much will be the shift in the interference pattern? The distance between the slits is 0.5 mm and that between slits and screen is 100 cm :

(A) 5 cm (B) 2.5 cm

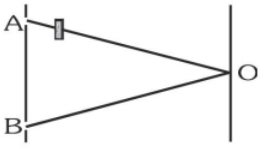
(C) 0.25 cm (D) 0.1 cm

Q19. InYoung's double slit experiment, a mica sheet of thickness t and refractive index μ is introduced in the path of ray from the first source S_1. By how much distance the fringe pattern will be displaced.

(A) $\frac{d}{D}(\mu - 1)t$ (B) $\frac{D}{d}(\mu - 1)t$

(C) $\frac{d}{(\mu - 1)D}$ (D) $\frac{D}{d}(\mu - 1)$

Q20. In Young's experiment, monochromatic light is used to illuminate the two slits A and B. Interference fringes are observed on a screen placed in front of the slits. Now if a thin glass plate is placed normally in the path of the beam coming from the slit then :



(A) the fringes will disappear
(B) the fringe width will decrease
(C) the fringe width will increase
(D) there will be no change in the fringe width

Q21. A ray of light is incident on the surface of a glass plate at an angle of incidence equal to Brewster's angle ϕ. If μ represents the refractive index of glass with respect to air, then the angle between reflected and refracted rays is :

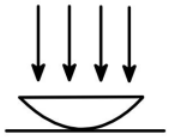
(A) $90 + \phi$ (B) $\sin^{-1}(\mu\cos\phi)$
(C) $90°$ (D) $90° - \sin^{-1}(\sin\phi/\mu)$

Q22. **Statement-1 :** In YDSE, as shown in figure, central bright fringe is formed at O. If a liquid is filled between plane of slits and screen, the central bright fringe is shifted in upward direction.

Statement-2 : If path difference at O increases, y-coordinate of central bright fringe will change.

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.
(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.
(C) Statement-1 is true, statement-2 is false.
(D) Statement-1 is false, statement-2 is true.

Q23. A thin slice is cut out of a glass cylinder along a plane parallel to its axis. The slice is placed on a flat glass plate as shown. The observed interference fringes from this combination shall be :



(A) Straight
(B) Circular
(C) Equally spaced
(D) Having fringe spacing which increases as we go outwards.

Diffraction

Q24. A light source of 5000Å wave length produces a single slit diffraction. The first minima in diffraction pattern is seen, at a distance of 5mm from central maxima. The distance between screen and slit is 2 metre. The width of slit in mm will be :

(A) 0.1 (B) 0.4
(C) 0.2 (D) 2

Q25. A plane wave front of wave length 6000 Å is incident upon a slit of 0.2mm width, which enables Fraunhofer's diffraction pattern to be obtained on a screen 2 metre away. Width of the central maxima in mm will be :

(A) 10 (B) 12
(C) 8 (D) 2

Q26. Central fringe obtained in diffraction pattern due to a single slit :–

(A) is of minimum intensity
(B) is of maximum intensity
(C) intensity does not depend upon slit width
(D) none of the above

Polarisation

Q27. Refractive index of water is 1.33. Calculate the angle of polarisation for light reflected from the surface of a lake.

(A) 60° (B) 53°

(C) 37° (D) 45°

Q28. A parallel beam of light is incident at an angle of 60° on a plane glass surface and the reflected beam is completely polarised. What is the angle of refraction in glass ?

(A) 60° (B) 53°

(C) 37° (D) 30°

Q29. The angle of incidence at which reflected light is totally polarized for reflection from air to glass (refractive index n).

(A) $\sin^{-1}(n)$ (B) $\sin^{-1}\left(\frac{1}{n}\right)$

(C) $\tan^{-1}\left(\frac{1}{n}\right)$ (D) $\tan^{-1}(n)$

Q30. A polaroid is placed at 45° to an incoming light of intensity I_0. Now the intensity of light passing through polaroid after polarisation would be :

(A) I_0 (B) $I_0/2$

(C) $I_0/4$ (D) Zero

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. To observe a sustained interference pattern formed by two light waves, it is not necessary that they must have :

(A) The same frequency

(B) Same amplitude

(C) A constant phase difference

(D) The same intensity

Q2. If the source of light used in a Young's Double Slit Experiment is changed from red to blue, then

(A) The fringes will become brighter

(B) Consecutive fringes will come closer

(C) The number of maxima formed on the screen increases

(D) The central bright fringe will become a dark fringe.

Q3. If one of the slits of a standard YDSE apparatus is covered by a thin parallel sided glass slab so that it transmit only one half of the light intensity of the other, then :

(A) The fringe pattern will get shifted towards the covered slit.

(B) The fringe pattern will get shifted away from the covered slit.

(C) The bright fringes will be less bright and the dark ones will be more bright.

(D) The fringe width will remain unchanged.

Q4. In a YDSE apparatus, if we use white light then :

(A) The fringe next to the central will be red

(B) The central fringe will be white.

(C) The fringe next to the central will be violet

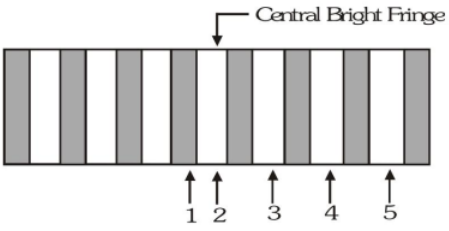
(D) There will not be a completely dark fringe.

PARAGRAPH TYPE

This section contains ***PARAGRAPHS****. Based on each paragraph, there are questions. Each question has FOUR options.* ***ONLY ONE*** *of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 5 to 7

The figure shows the interference pattern obtained in a double–slit experiment using light of wavelength 600nm.



Q5. The third order bright fringe is :

(A) 2 (B) 3 (C) 4 (D) 5

Q6. Which fringe results from a phase difference of 4π between the light waves incidenting from two slits?

(A) 2 (B) 3 (C) 4 (D) 5

Q7. Let ΔX_A and ΔX_C represent path differences between waves interfering at 1 and 3 respectively then $(|\Delta X_C| - (|\Delta X_A|)$ is equal to :

(A) 0 (B) 300 mn

(C) 600 nm (D) 900 nm

Paragraph for Question No. 8 to 10

The lens governing the behavior of the rays namely rectilinear propagation, laws of reflection and refraction can be summarised in one fundamental law known as Fermat's principle. According to this principle a ray of light travels from one point to another such that the time taken is at a stationary value (maximum or minimum). If c is the velocity of light in a vacuum, the velocity in a medium of refractive index μ is $\frac{c}{\mu}$, hence time taken to travel a distance ℓ is $\frac{\mu\ell}{c}$. If the light passes through a number of media, the total time taken is $\left(\frac{1}{c}\right)\sum\mu\ell$ or $\frac{1}{c}\int\mu d\ell$ if refractive index varies continuously.

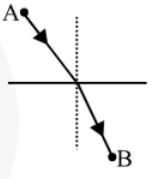
Now, $\sum\mu\ell$ is the total optical path, so that Fermat's principle states that the path of a ray is such that the optical path in at a stationary value. This principle is obviously in agreement with the fact that the ray are straight lines in a homogenous isotropic medium. It is found that it also agrees with the classical laws of reflection and refraction.

Q8. If refractive index of a slab varies as $\mu = 1 + x^2$ where x is measured from one end, then optical path length of a slab of thickness 1 m is :

(A) $\frac{4}{3}$m (B) $\frac{3}{4}$m

(C) 1 m (D) None

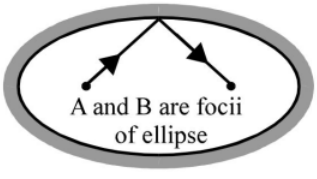
Q9. The optical path length followed by ray from point A to B given that laws of refraction are obeyed as shown in figure is :-



(A) Maximum (B) Minimum

(C) Constant (D) None

Q10. The optical path length followed by ray from point A to B given that laws of reflection are obeyed as shown in figure is :



(A) Maximum (B) Minimum

(C) Constant (D) None

SUBJECTIVE TYPE

Q11. Waves emitted by two identical sources produces intensity of K unit at a point on screen where path difference between these waves is λ, calculate the intensity at that point on screen at which path difference is $\frac{\lambda}{4}$.

Q12. In young's double slit experiment, two slits are separated by 3mm distance and illuminated by light of wavelength 480 nm. The screen is at 2m from the plane of the slits. Calculate the separation between the 8th Bright fringe and the 3rd dark fringe obtained on same side of central Bright fringe.

Exercise - 2 *Brain Booster*

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. Two coherent sources of equal intensities produce a maximum of 100 units. If the amplitude of one of the sources is reduced by 20%, then the maximum intensity produced will be :

(A) 100 (B) 81

(C) 89 (D) 60

Q2. Two waves $Y_1 = a\sin\omega t$ and $Y_2 = a\sin(\omega t+\delta)$ are producing interference, then resultant intensity is :-

(A) $a^2\cos^2\left(\frac{\delta}{2}\right)$ (B) $2a^2\cos^2\left(\frac{\delta}{2}\right)$

(C) $3a^2\cos^2\left(\frac{\delta}{2}\right)$ (D) $4a^2\cos^2\left(\frac{\delta}{2}\right)$

Q3. In Young's double slit experiment, if the width of the slits are in the ratio 4 : 9 the ratio of the intensity of maxima to the intensity at minima will be :

(A) 169 : 25 (B) 81 : 16

(C) 25 : 1 (D) 9 : 4

Q4. The path difference between two interfering waves at a point on the screen is $\lambda/6$. The ratio of intensity at this point and that at the central bright fringe will be :

(Assume that intensity due to each slit is same)

(A) 0.853 (B) 8.53 (C) 0.75 (D) 7.5

Q5. In a young double slit experiment, 12 fringes are observed to be formed in a certain segment of the screen when light of wavelength 600 nm is used. If the wavelength of light is changed to 400 nm, number of fringes observed in the same segment of the screen is given by :

(A) 12 (B) 18 (C) 24 (D) 30

Q6. In Young's double slit experiment, the wavelength of red light is 7800 Å and that of blue light is 5200Å. The value of n for which n^{th} bright band due to red light coincides with $(n+1)^{th}$ bright band due to blue light, is :

(A) 1 (B) 2 (C) 3 (D) 4

Q7. In Young's double slit experiment, the two slits act as coherent sources of equal amplitude A and wavelength λ. In another experiment with the same setup the two slits are sources of equal amplitude A and wavelength λ but are incoherent. The ratio of the average intensity of light at the midpoint of the screen in the first case to that in the second case is :-

(A) 1 : 1 (B) 2 : 1

(C) 4 : 1 (D) none of these

Q8. If intensity of each wave in the observed interference pattern in Young's double slit experiment is I_0, then for some point P where the phase difference is ϕ , intensity I will be:

(A) $I = I_0 \cos\phi$ (B) $I = I_0 \cos^2 \phi$

(C) $I = I_0 (1+\cos\phi)$ (D) $I = 2I_0(1+\cos\phi)$

Q9. In Young's double slit experiment, one of the slits is so painted that intensity of light emitted from it is half of that of the light emitted from other slit. Then :-

(A) Fringe system will disappear

(B) Bright fringes will become brighter and dark fringes will be darker

(C) Both bright and dark fringes will become darker

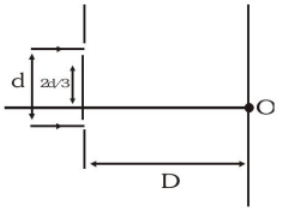
(D) Dark fringes will become less dark and bright fringes will become less bright.

Q10. Two beams of light having intensities I and 4I interfer to produce a fringe pattern on a screen. The phase difference between the beam is $\frac{\pi}{2}$ at point A and 2π at point B. Then find out the difference between the resultant intensities at A and B.

(A) 2I (B) 5I

(C) I (D) 4I

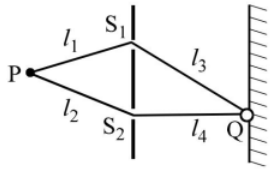
Q11. In the figure shown if a parallel beam of white light is incident on the plane of the slits then the distance of the nearest white spot on the screen from O is : [assume d << D, λ << d]



(A) 0 (B) d/2

(C) d/3 (D) d/6

Q12. Two identical narrow slits S_1 and S_2 are illuminated by light of wavelength λ from a point source P. If, as shown in the diagram, the light is then allowed to fall on a screen, and if n is a positive integer, the condition for destructive interference at Q is :-



(A) $(\ell_1 - \ell_2) = (2n + 1)\lambda/2$

(B) $(\ell_3 - \ell_4) = (2n + 1)\lambda/2$

(C) $(\ell_1 + \ell_2) - (\ell_3 + \ell_4) = n\lambda$

(D) $(\ell_1 + \ell_3) - (\ell_2 + \ell_4) = (2n + 1)\lambda/2$

Q13. In YDSE, the source placed symmetrically with respect to the slit is now moved parallel to the plane of the slits so that it is closer to the upper slit, as shown. Then :-

(A) The fringe width will increase and fringe pattern will shift down.

(B) The fringe width will remain same but fringe pattern will shift up.

(C) The fringe width will decrease and fringe pattern will shift down.

(D) The fringe width will remain same but fringe pattern will shift down.

Q14. In Young's experiment, light of wavelength 6000Å is used to produce fringes of width 0.8 mm at a distance of 2.5 m. If the whole experiment is deep in a liquid of refractive index 1.6, then fringe width will be :

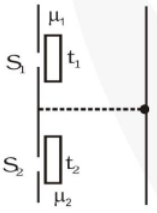
(A) 0.5 mm (B) 0.6 mm

(C) 0.4 mm (D) 0.2 mm

Q15. The central fringe of interference pattern produced by light of wavelength 6000Å is found to shift to the position of 4th bright fringe, after a glass plate of $\mu = 1.5$ is introduced. The thickness of the glass plate is :

(A) 4.8 μm (B) 8.23 μm
(C) 14.98 μm (D) 3.78 μm

Q16. In a Young's double slit experiment, a slab of thickness 1.2 μm and refractive index 1.5 is placed in front of one slit and another slab of thickness t and refractive index 2.5 is placed in front of the second slit. If the position of the central fringe remains unaltered, then the thickness t is :-



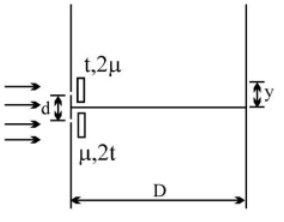
(A) 0.4 μm (B) 0.8 μm
(C) 1.2 μm (D) 7 μm

Q17. In the ideal double–slit experiment, when a glass–plate (refractive index 1.5) of thickness t is introduced in the path of one of the interfering beams (wavelength λ), the intensity at the position

where the central maximum occurred previously remains unchanged. The minimum thickness of the glass–plate is :-

(A) 2λ (B) $\frac{2\lambda}{3}$ (C) $\frac{\lambda}{3}$ (D) λ

Q18. In the YDSE shown the two slits are covered with thin sheets having thickness t & $2t$ and refractive index 2μ and μ. Find the position (y) of central maxima.



(A) zero (B) $\frac{tD}{d}$

(C) $-\frac{tD}{d}$ (D) None

Q19. A thin film of thickness t and index of refraction 1.33 coats a glass with index of refraction 1.50. What is the least thickness t that will strongly reflect light with wavelength 600 nm incident normally?

(A) 226 nm (B) 300 nm
(C) 400 nm (D) 450 nm

Q20. In a single slit diffraction experiment first minimum for $\lambda_1 = 660$ nm coincides with first maxima for wavelength λ_2. Calculate λ_2.

(A) 550 nm (B) 400 nm
(C) 440 nm (D) 660 nm

Q21. Find the half angular width of the central bright maximum in the Fraunhofer diffraction pattern of a slit of width 12×10^{-5} cm, when the slit is illuminated by monochromatic light of wavelength 6000 Å.

(A) 40° (B) 45°
(C) 30° (D) 60°

Q22. The angle of polarisation for any medium is 60°, what will be critical angle for this :

(A) $\sin^{-1}\sqrt{3}$ (B) $\tan^{-1}\sqrt{3}$

(C) $\cos^{-1}\sqrt{3}$ (D) $\sin^{-1}\frac{1}{\sqrt{3}}$

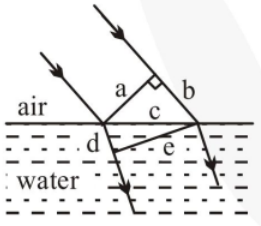
Q23. Two Nicols are oriented with their principal planes making an angle of 60°. The percentage of intansity of incident unpolarized light which passes through the system is :

(A) 50% (B) 100%
(C) 12.5% (D) 37.5%

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Figure shows plane waves refracted from air to water using Huygen's principle (where a, b, c, d, e are lengths on the diagram). The refractive index of water wrt air is the ratio:-



(A) a/e (B) b/e
(C) b/d (D) d/b

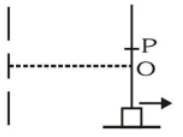
Q2. If the first minima in a Young's slit experiment occurs directly in front of one of the slits, (distance between slit & screen D = 12 cm and distance between slits d = 5 cm) then the wavelength of the radiation used can be :

(A) 2 cm (B) 4 cm
(C) $\frac{2}{3}$ cm (D) $\frac{4}{3}$ cm

Q3. In young's double slit experiment, slits are arranged in such a way that besides central bright fringe, there is only one bright fringe on either side of it. Slit separation d for the given condition cannot be (if λ is wavelength of the light used) :

(A) λ (B) $\lambda/2$
(C) 2λ (D) $3\lambda/2$

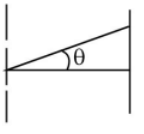
Q4. In a Young's Double slit experiment, first maxima is observed at a fixed point P on the screen. Now the screen is continuously moved away from the plane of slits. The ratio of intensity at point P to the intensity at point O (centre of the screen) :-



(A) Remains constant
(B) Keeps on decreasing
(C) First decreases and then increases
(D) First decreases and then becomes constant

Q5. Two slits are separated by 0.3 mm. A beam of 500 nm light strikes the slits producing an interference pattern. The number of maxima observed in the angular range $-30° < \theta < 30°$.

(A) 300
(B) 150
(C) 599
(D) 601



Q6. In a YDSE bi–chromatic light of wavelengths 400nm and 560 nm are used. The distance between the slits is 0.1 mm and the distance between the plane of the slits and the screen is 1m. The minimum distance between two successive regions of complete darkness is :–

(A) 4 mm (B) 5.6 mm
(C) 14 mm (D) 28 mm

Q7. In Young's double slit experiment intensity at a point is (1/4) of the maximum intensity. Angular position of this point is :–

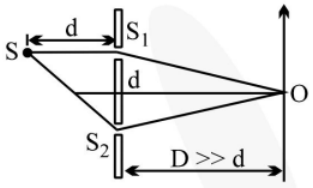
(A) $\sin^{-1}\left(\frac{\lambda}{d}\right)$ (B) $\sin^{-1}\left(\frac{\lambda}{2d}\right)$
(C) $\sin^{-1}\left(\frac{\lambda}{3d}\right)$ (D) $\sin^{-1}\left(\frac{\lambda}{4d}\right)$

Q8. In a Young's double slit experiment D equals the distance of screen and d is the separation between the slit. The distance of the nearest point to the central maximum where the intensity is same as that due to a single slit, is equal to :-

(A) $\frac{D\lambda}{d}$ (B) $\frac{D\lambda}{2d}$

(C) $\frac{D\lambda}{3d}$ (D) $\frac{2D\lambda}{d}$

Q9. To make the central fringe at the centre O, a mica sheet of refractive index 1.5 is introduced. Choose the correct statements (s).



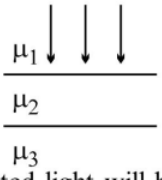
(A) The thickness of sheet is $2(\sqrt{2}-1)d$ in front of S_1.

(B) The thickness of sheet is $(\sqrt{2}-1)d$ in front of S_2.

(C) The thickness of sheet is $2\sqrt{2}\,d$ in front of S_1.

(D) The thickness of sheet is $(2\sqrt{2}-1)d$ in front of S_1.

Q10. Consider a case of thin film interference as shown. Thickness of film is equal to wave-length of light in μ_2.



(A) Reflected light will be maxima if $\mu_1 < \mu_2 < \mu_3$

(B) Reflected light will be maxima if $\mu_1 < \mu_2 > \mu_3$

(C) Transmitted light will be maxima if $\mu_1 > \mu_2 > \mu_3$

(D) Transmitted light will be maxima if $\mu_1 > \mu_2 < \mu_3$

Q11. In a Young's double-slit experiment, let A and B be the two slits. Films of thicknesses t_A and t_B and refractive indices μ_A and μ_B, are placed in front of A and B respectively.

If $\mu_A t_A = \mu_B t_B$, the central maximum will :

(A) not shift

(B) shift towards A

(C) shift towards B

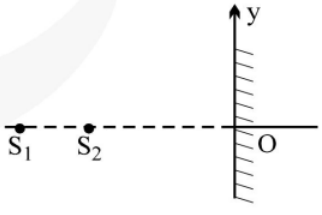
(D) option (B), if $t_B > t_A$; option (C) if $t_B < t_A$

Q12. It is necessary to coat a glass lens with a non-reflecting layer. If the wavelength of the light in the coating is λ, the best choice is a layer of material having an index of refraction between those of glass and air and a minimum thickness of :-

(A) $\frac{\lambda}{4}$ (B) $\frac{\lambda}{2}$

(C) $\frac{3\lambda}{8}$ (D) λ

Q13. Two point monochromatic and coherent sources of light of wavelength λ are placed on the dotted line in front of a large screen. The sources emit waves in phase with each other. The distance between S_1 and S_2 is d while their distance from the screen is much larger. Which is the set of correct statement:



(A) If d = 7 λ/2, O will be a minima

(B) If d = 4.3 λ, there will be a total of 8 minima on y-axis.

(C) If d = 7 λ, O will be a maxima.

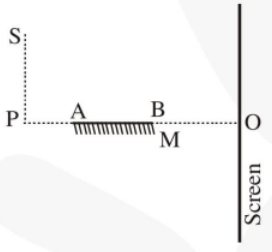
(D) If d = λ, there will be only one maxima on the screen.

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 14 and 15

In an experiment on interference due to single mirror, a light wave emitted directly by the source S (narrow slit) interferes with the wave reflected from the mirror M of length 2 mm. Source and screen are separated by distance 90 cm. Source *S* is at the height of 3 mm, from the point P and the middle point of mirror is at distance of 2mm from point *P*. Point *P* and mirror are in the same plane of screen is perpendicular to this plane.



Q14. If fringe width is 0.1 mm then what is the wavelength of light used ?

(A) 3.3×10^{-7} m

(B) 6.7×10^{-7} m

(C) 1.0×10^{-7} m

(D) 4×10^{-7} m

Q15. If the mirror is shifted towards left then how does the fringe pattern on screen change?

(A) Fringe width decreases and the region in which interference is formed shifts downward.

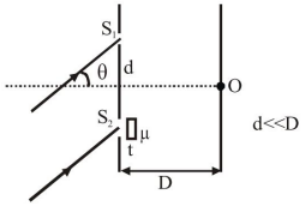
(B) Fringe width decreases and region in which inteference is formed shifts upwards.

(C) Fringe width does not change and region in which interference is formed shifts upwards.

(D) Fringe width does not change and region in which inteference is formed shifts downwards.

Paragraph for Question No. 16 to 18

A monochromatic beam of light falls on Young's double slit experiment apparatus as shown in figure. A thin sheet of glass is inserted in front of lower slit S_2.



Q16. The central bright fringe can be obtained

(A) at O only

(B) at O or below O only

(C) at O or above O only

(D) Anywhere on the screen

Q17. If central bright fringe is obtained on screen at *O* :-

(A) $(\mu-1)\, t = d\sin\theta$

(B) $(\mu-1)\, t = d\cos\theta$

(C) $(\mu-1)t + d\sin\theta = 0$

(D) $\dfrac{t}{\mu-1} = \dfrac{d}{\sin\theta}$

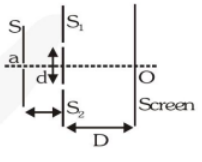
Q18. The phase difference between the waves interfering at fifth minima is :-

(A) 5π (B) 7π

(C) 9π (D) 11π

Paragraph for Question No. 19 to 21

The figure shows a schematic diagram showing the arrangement of Young's Double Slit Experiment :



Q19. Choose the correct statement(s) related to the wavelength of light used

(A) Larger the wavelength of light larger the fringe width.

(B) The position of central maxima depends on the wavelength of light used.

(C) If white light is used in YDSE, then the violet colour forms its first maxima closest to the central maxima.

(D) The central maxima of all the wavelengths coincide.

Q20. If the distance D is varied, then choose the correct statement(s)

(A) The angular fringe width does not change

(B) The fringe width changes in direct proportion

(C) The change in fringe width is same for all wavelengths

(D) The position of central maxima remains unchanged

Q21. If the distance d is varied, then identify the correct statement(s)

(A) The angular width does not change.

(B) The fringe width changes in inverse proportion.

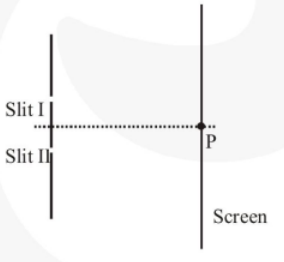
(C) The positions of all maxima change.

(D) The positions of all minima change.

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q22. A double slit interference pattern is produced on a screen, as shown in the figure, using monochromatic light of wavelength 500nm. Point P is the location of the central bright fringe, that is produced when light waves arrive in phase without any path difference. A choice of three strips A, B and C of transparent materials with different thicknesses and refractive indices is available, as shown in the table. These are placed over one or both of the slits, singularly or in conjunction, causing the interference pattern to be shifted across the screen from the original pattern. In the column–I, how the strips have been placed, is mentioned whereas in the column–II, order of the fringe at point P on the screen that will be produced due to the placement of the strips(s), is shown. Correctly match both the column.



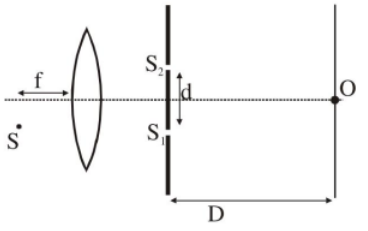
Film	A	B	C
Thickness (in μm)	5	1.5	0.25
Refractive index	1.5	2.5	2

Column I	**Column II**
(A) Only strip B is placed over slit–I	(P) First Bright
(B) Strip A is placed over slit–I and strip C is placed over slit–II	(Q) Fourth Dark
(C) Strip A is placed over the slit–I and strip B and strip C are placed over the slit–II in conjunction	(R) Fifth Dark
(D) Strip A and strip C are placed over slit–I (in conjuction) Bright and strip B is placed over Slit–II	(S) Central

Q23. Column-I shows some modifications in a standard YDSE setup. Column-II shows the associated characteristics.

Column-I **Column-II**

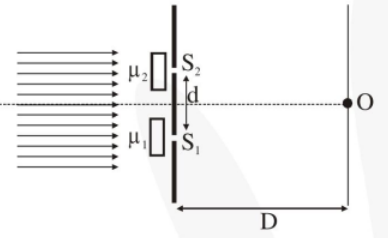
(A)



monochromatic point source S placed in focal plane.

(P) Zero order maxima lies above O.

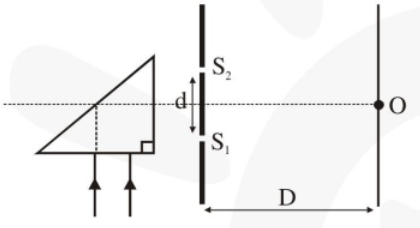
(B)



monochromatic parallel beam incident on S_1S_2 through transparent slabs of same thickness but $\mu_1 > \mu_2$

(Q) If a transparent mica sheet is introduced infront of S_2 central bright fringe can be obtained at O.

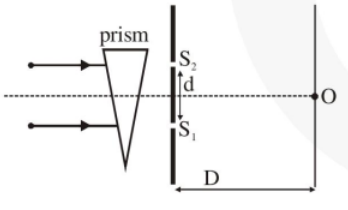
(C)



monochromatic parallel beam incident on a right angled isosceles prism of refractive index 1.50

(R) Fringe width $\beta = \frac{\lambda D}{d}$

(D)



monochromatic parallel beam incident on thin prism

(S) Point O can be a minima

(T) Point O can be a least order minima.

NUMERICAL TYPE

Q24. In young's double slit experiment, the slits are 2mm apart and are illuminated with a mixture of two wavelength, $\lambda = 7500Å$ and $\lambda' = 9000Å$. At what minimum distance from the common central on a screen 2m from the slits will a bright fringe from one interference pattern coincide with a bright fringe from the other.

Answer Key

Ex-1									
1	2	3	4	5	6	7	8	9	10
D	A	A	D	D	A	D	A	D	D
11	12	13	14	15	16	17	18	19	20
A	D	A	C	C	C	D	B	B	D
21	22	23	24	25	26	27	28	29	30
C	D	A	C	B	B	B	D	D	B

Ex-1A

1. B,D **2.** B,C **3.** A,C,D **4.** B,C,D **5.** D

6. C **7.** B **8.** A **9.** B **10.** C

11. $\frac{K}{2}$ unit **12.** 1.76×10^{-3} m

Ex-2									
1	2	3	4	5	6	7	8	9	10
B	D	C	C	B	B	B	D	D	D
11	12	13	14	15	16	17	18	19	20
D	D	D	A	A	A	A	B	A	C
21	22	23							
C	D	C							

Ex-2A

1. C **2.** A,C **3.** A,B **4.** C **5.** C

6. D **7.** C **8.** C **9.** A **10.** A,D

11. D **12.** A **13.** C **14.** B **15.** C

16. D **17.** A **18.** C **19.** A,C,D **20.** A,B,D

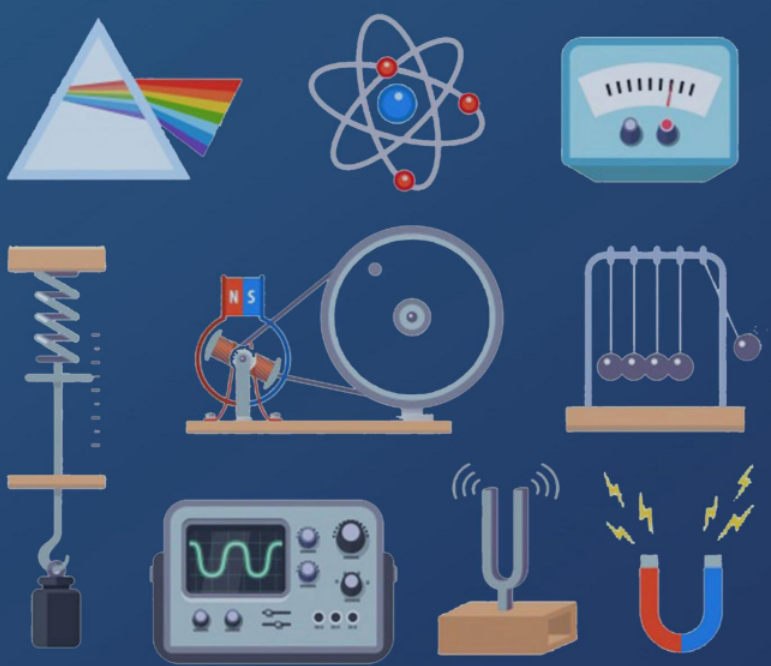
21. B,C,D

22. (A) → (R) ; (B) → (R) ; (C) → (S) ; (D) → (P)

23. (A) → (PRST); (B) → (QRST); (C) → (R); (D) → (PRST) **24.** 4.5 mm

PHYSICS

Work, Power & Energy



SHEET

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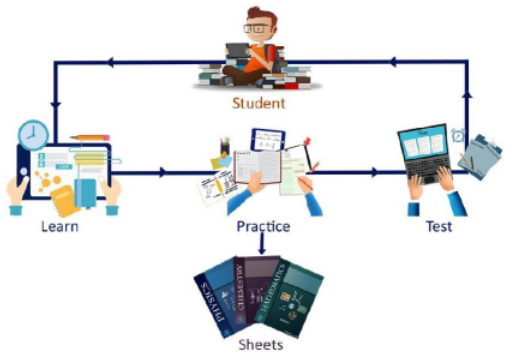
Note

Detailed solutions are available on the eSaral App.

Module Description



For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No	Topic Name	Ex 1	Ex 1A	Ex 2	Ex 2A
1	Work - Introduction	1-5	19	1	
2	Work done by Constant and Variable Force	6,7	15,20,26	2 to 5	1,13,14, 27-30
3	Work done by Spring			6,7	31
4	Work Energy Theorem for a Particle	8-13	1,16	8-15	2,32
5	Vertical Circular Motion	14	17	16,17	3, 4, 15-19, 22
6	Work Energy Theorem for a System	15-16	21	18-25	20,21,23, 33,37,38
7	Central and Tangential Forces		2		5
8	Conservative Forces	17	3,22	26	6
9	Potential Energy	18,19	18,23	27,28	
10	Mechanical Energy and its Conservation	20-24	4	29 to 38	26
11	Equilibrium	25			7
12	Power	26-28	24	39,40	39,40
13	After Full Chapter		5-14, 25, 27		8-12, 24-25, 34-36, 41

Exercise - 1 — Concept Builder

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Introduction

Q1. A bicyclist comes to a skidding stop in 10 m. During this process, the force on the bicycle due to the road is 200N and is directly opposed to the motion. The work done by the cycle on the road is ?

(A) + 2000J (B) – 200J

(C) zero (D) – 20,000J

Q2. A rope is used to lower vertically a block of mass M by a distance x with a constant downward acceleration g/2. The work done by the rope on the block is :

(A) Mgx (B) $\frac{1}{2}$ Mgx

(C) $-\frac{1}{2}$ Mgx (D) Mgx^2

Q3. A block of mass 5 kg slides down a rough inclined surface. The angle of inclination is 45°. The coefficient of sliding friction is 0.20. When the block slides 10 m; the work done on the block by force of friction is :-

(A) $50\sqrt{2}$ J (B) $-50\sqrt{2}$ J

(C) 50 J (D) –50 J

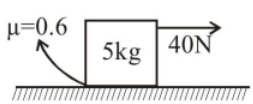
Q4. A 40N force start acting on a particle of mass 5kg, which is resting on a rough surface. If co-efficient of friction between block and surface is $\mu = 0.6$. Find work done by firction in 3 seconds :-

(A) –90 J

(B) –60 J

(C) –180 J

(D) –270 J



Q5. A body moves a distance of 10 m along a straight line under the action of a force 5 N. If the work done is 25 joules, the angle which the force makes with the direction of motion of the body is :-

(A) 0° (B) 30°

(C) 60° (D) 90°

Work done by Constant and Variable Force

Q6. A force of magnitude of 30 N acting along $\hat{i}+\hat{j}+\hat{k}$, displaces a particle from point (2, 4, 1) to (3, 5, 2). The work done during this displacement is -

(A) 90 J (B) 30 J

(C) $30\sqrt{3}$ J (D) $30/\sqrt{3}$ J.

Q7. $\vec{F}=(\hat{i}+\hat{j})$ newton, displacement $\vec{S}=(3\hat{i}+4\hat{j})$ metre work done is :-

(A) 3J (B) 4J (C) 7J (D) 5J

Work Energy Theorem for a Particle

Q8. Work done in time t on a body of mass m which is accelerated from rest to a speed v in time t_1 as a function of time t is given by:

(A) $\frac{1}{2}m\frac{v}{t_1}t^2$ (B) $m\frac{v}{t_1}t^2$

(C) $\frac{1}{2}\left(\frac{mv}{t_1}t\right)^2 t^2$ (D) $\frac{1}{2}m\frac{v^2}{t_1^2}t^2$

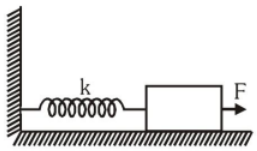
Q9. A ball with mass m projected horizontally off the end of a table with an initial kinetic energy K. At a time t after it leaves the end of the table it has kinetic energy 3K. What is t? Neglect air resistance.

(A) $(3/g)\sqrt{K/m}$ (B) $(2/g)\sqrt{K/m}$

(C) $(1/g)\sqrt{8K/m}$ (D) $(K/g)\sqrt{6/m}$

Q10. A block attached to a spring, pulled by a constant horizontal force, is kept on a smooth surface as shown in the figure. Initially, the spring is in the natural state. Then the maximum positive work that the applied force F can do is :

[Given that spring does not break]



(A) $\frac{F^2}{k}$ (B) $\frac{2F^2}{k}$ (C) ∞ (D) $\frac{F^2}{2k}$

Q11. A particle of mass 100 g is thrown vertically upwards with a speed of 5 m/s. The work done by the force of gravity during the time the particle goes up is -

(A) – 0.5 J (B) –1.25 J

(C) 1.25 J (D) 0.5 J

Q12. A constant force of 5 N is applied on a block of mass 20 kg for a distance of 2.0 m, the kinetic energy acquired by the block is :-

(A) 20 J (B) 15 J

(C) 10 J (D) 5 J

Q13. A particle of mass 2kg travel as per $x = \frac{t^3}{3}$ where x & t are in m & s. Total work done in 0 to 2 sec is :-

(A) 1.6 J (B) 16 J

(C) 160 J (D) 1600 J

Vertical Circular Motion

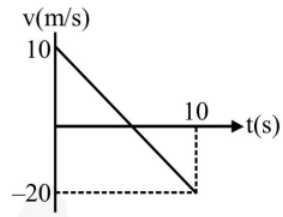
Q14. A particle of mass m is fixed to one end of a light rigid rod of length ℓ and rotated in a vertical circular path about its other end. The minimum speed of the particle at its highest point must be :

(A) zero (B) $\sqrt{g\ell}$

(C) $\sqrt{1.5g\ell}$ (D) $\sqrt{2g\ell}$

Work Energy Theorem for a System

Q15. Velocity time graph of a particle moving in a straight line is as shown in figure. Mass of the particle is 2kg. Work done by all the forces acting on the particle in time interval between t = 0 to t = 10 s is :-



(A) 300 J (B) –300 J

(C) 400 J (D) –400 J

Q16. Two bodies of masses 1 kg and 5 kg are dropped gently from the top of a tower. At a point 20 cm from the ground, both the bodies will have the same :-

(A) Momentum

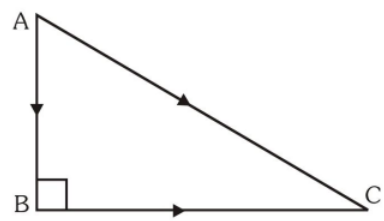
(B) Kinetic energy

(C) Velocity

(D) Total energy

Conservative Forces

Q17. The work done in moving a particle under the effect of a conservative force, from position A to B is 3 joule and from B to C is 4 joule. The work done in moving the particle from A to C is :



(A) 5 joule (B) 7 joule

(C) 1 joule (D) –1 joule

Potential Energy

Q18. The potential energy of a body is given by, $U = A - Bx^2$ (Where x is the displacement). The magnitude of force acting on the particle is :-

(A) Constant

(B) Proportional to x

(C) Proportional to x^2

(D) Inversely proportional to x

Q19. The potential energy for a force field $\vec{F}$ is given by U(x,y) = cos (x + y). The force acting on a particle at position given by coordinates $\left(0, \frac{\pi}{4}\right)$ is :-

(A) $-\frac{1}{\sqrt{2}}(\hat{i}+\hat{j})$ (B) $\frac{1}{\sqrt{2}}(\hat{i}+\hat{j})$

(C) $\left(\frac{1}{2}\hat{i}+\frac{\sqrt{3}}{2}\hat{j}\right)$ (D) $\left(\frac{1}{2}\hat{i}-\frac{\sqrt{3}}{2}\hat{j}\right)$

Mechanical Energy and its Conservation

Q20. A marble of mass m and radius b is placed in a hemispherical bowl of radius r. The minimum velocity to be given to the marble so that it reaches the highest point is :

(A) $\sqrt{2g(r-b)}$ (B) $\sqrt{2gr}$

(C) $\sqrt{2g(r+b)}$ (D) $\sqrt{g(r-b)}$

Q21. A pendulum bob has been pulled aside from its equilibrium position through an angle α and then released. If ℓ is the length of the pendulum,then the bob will reach the equilibrium position with speed of :-

(A) $\sqrt{2g\ell}$ (B) $\sqrt{2g\ell\cos\alpha}$

(C) $\sqrt{2g\ell(1-\cos\alpha)}$ (D) $\sqrt{2g\ell(1-\sin\alpha)}$

Q22. When a conservative force does positive work on a body :

(A) The potential energy increases

(B) The potential energy decreases

(C) Total energy increases

(D) Total energy decreases

Q23. When a conservative force does positive work then potential energy of the system associated with that force.

(A) decreases

(B) increases

(C) remain constant

(D) depends on whether other non-conservative force is working or not.

Q24. A ball of mass 0.2 kg is thrown vertically upwards by applying a force by hand. If the hand moves 0.2 m while applying the force and the ball goes upto 2m height further, find the magnitude of force.

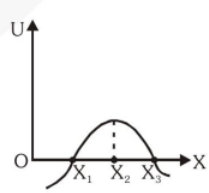
[Take g = 10 m/s^2]

(A) 22N (B) 4N

(C) 16 N (D) 20 N

Equilibrium

Q25. In the figure shown the potential energy (U) of a particle is plotted against its position 'x' from origin. Then which of the following statement is correct. A particle at :



(A) x_1 is in stable equilibrium

(B) x_2 is in stable equilibrium

(C) x_3 is in stable equilibrium

(D) None of these

Power

Q26. A body of mass m accelerates uniformly from rest to v_1 in time t_1. The instantaneous power delivered to the body as a function of time t is-

(A) $\frac{mv_1t}{t_1}$ (B) $\frac{mv_1^2t}{t_1^2}$

(C) $\frac{mv_1t^2}{t_1}$ (D) $\frac{mv_1^2t}{t_1}$

Q27. An elevator with passengers has a total mass of 800 kg and moves slowly a vertical distance of 20.0 m in 10.0 s. What is the average power expended in lifting this mass?

(A) 1.57×10^2 W (B) 1.57×10^4 W

(C) 1.57×10^5 W (D) 1.57×10^6 W

Q28. A force of 10 N is applied on a body for 3 s and the corresponding displacement is 6m. The power of the source is :-

(A) 20 W (B) 25 W

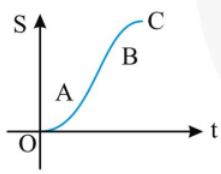
(C) 40 W (D) 50 W

Exercise - 1A *Concept Builder*

ONE OR MORE THAN ONE CORRECT TYPE

Each question has FOUR options for correct answer(s). ***ONE OR MORE THAN ONE*** *of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Displacement time graph of a particle moving in a straight line is as shown in figure. select the correct alternative (s):



(A) Work done by all the forces in region OA and BC is positive.

(B) Work done by all the forces in region AB is zero.

(C) Work done by the forces in region BC is negative.

(D) Work done by all the forces in region OA is negative.

Q2. Which of the following is/are conservative force(s)?

(A) $\vec{F} = 2r^3\hat{r}$ (B) $\vec{F} = -\frac{5}{r}\hat{r}$

(C) $\vec{F} = \frac{3(x\hat{i} + y\hat{j})}{(x^2+y^2)^{3/2}}$ (D) $\vec{F} = \frac{3(y\hat{i} + x\hat{j})}{(x^2+y^2)^{3/2}}$

Q3. If one of the forces acting on a particle is conservative then :

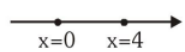
(A) Its work is zero when the particle moves exactly once around any closed path.

(B) Its work equals the change in the kinetic energy of the particle.

(C) It obeys Newton's second law.

(D) Its work depends on the end points of the motion, not on the path between.

Q4. A particle of mass m = 1 kg lying on x–axis experiences a force given by law F = x(3x–2) Newton, where x is the x–coordinate of the particle in meters. The points on x–axis where the particle is in equilibrium are :



(A) x = 0 (B) x = 1/3

(C) x = 2/3 (D) x = 1

Q5. A jumper jumps upwards with some acceleration. Choose the **CORRECT** statement (s) :-

(A) The force exerted by the ground on him while he is attempting to jump is greater than his weight.

(B) Work is done by normal force on him while he attempts to jump.

(C) Since the feet touching ground remain at rest while he is attempting to jump, force exerted by ground on him is equal to his weight.

(D) Since the feet touching ground remain at rest while he is attempting to jump, work done by the force exerted by ground on him is zero.

Q6. Choose the correct alternative(s) :

(A) When a conservative force does positive work, the potential energy of the system decreases.

(B) Work done by friction on a body always results in a loss of its kinetic energy.

(C) Work done in the motion of a body over a closed loop is zero for every force in nature.

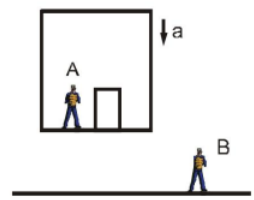
(D) Work done by friction on a body may increase its kinetic energy.

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 7 to 11

A block of mass m is kept in an elevator which starts moving downward with an acceleration a as shown in figure. The block is observed by two observers A and B for a time interval t_0.



Q7. The observer B finds that the work done by gravity is

(A) $\frac{1}{2}mg^2t_0^2$ (B) $-\frac{1}{2}mg^2t_0^2$

(C) $\frac{1}{2}mgat_0^2$ (D) $-\frac{1}{2}mgat_0^2$

Q8. The observer B finds that work done by normal reaction N is

(A) zero (B) $-Nat_0^2$

(C) $+\frac{Nat_0^2}{2}$ (D) None of these

Q9. The observer B finds that work done by pseudo force is

(A) zero (B) $-ma^2t_0$

(C) $+ ma^2t_0$ (D) $-mgat_0$

Q10. According to observer B, the net work done on the block is

(A) $-\frac{1}{2}ma^2t_0^2$ (B) $\frac{1}{2}ma^2t_0^2$

(C) $\frac{1}{2}mgat_0^2$ (D) $-\frac{1}{2}mgat_0^2$

Q11. According to the observer A

(A) The work done by gravity is zero

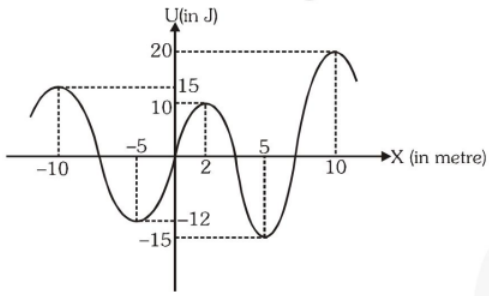
(B) the work done by normal reaction is zero

(C) The work done by pseudo force is zero

(D) All the above

Paragraph for Question no. 12 to 14

In the figure the variation of potential energy of a particle of mass m=2kg is represented w.r.t. its x-coordinate. The particle moves under the effect of this conservative force along the x- axis.



Q12. If the particle is released at the origin then :
(A) It will move towards positive x-axis.
(B) It will move towards negative x-axis.
(C) It will remain stationary at the origin.
(D) Its subsequent motion cannot be decided due to lack of information.

Q13. If the particle is released at $x = 2 + \Delta$ where $\Delta \to 0$ (it is positive) then its maximum speed in subsequent motion will be-

(A) $\sqrt{22}$ m/s (B) $\sqrt{25}$ m/s

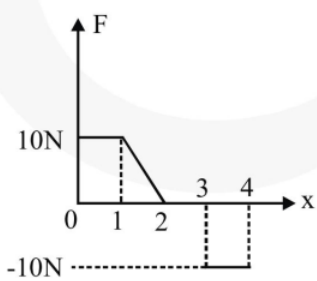
(C) $\sqrt{24}$ m/s (D) $\sqrt{23}$ m/s

Q14. x = –5 m and x = 10 m positions of the particle are respectively of-
(A) Neutral and stable equilibrium
(B) Neutral and unstable equilibrium
(C) Unstable and stable equilibrium
(D) Stable and unstable equilibrium.

MATCH THE COLUMN TYPE

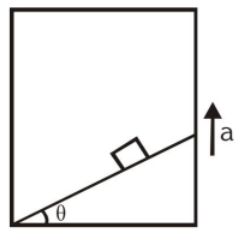
*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q15. A variable force whose variation is shown in force–position graph below. For each of the position indicated in column-I, match appropriate description in column-II. The force is acting on a body of mass 1 kg initially at rest at x = 0.



Column I	Column II
(A) $0 < x < 1$	(P) speed is increasing
(B) $1 < x < 2$	(Q) work done by the force is positive
(C) $2 < x < 3$	(R) body moves in positive x-direction
(D) $3 < x < 4$	(S) speed is decreasing

Q16. A block of mass m is stationary with respect to a rough wedge as shown in figure. Starting from rest, in time t work done on the block : ($m = 1kg$, $\theta = 30°$, $a = 2m/s^2$, $t = 4s$)

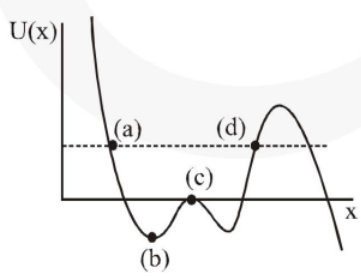


Column I	**Column II**
(A) By gravity	(P) 144 J
(B) By normal reaction	(Q) 32 J
(C) By friction	(R) 56 J
(D) By all the forces	(S) 48 J
	(T) None

Q17. In vertical circular motion of a bob, match the entries of column–I with entries of column–II. Here v_0 is the velocity of bob at lowest point & T is tension in string.

Column – I (Speed at lowest point)	**Column–II (Possible situation)**
(A) $v_0 = \sqrt{5g\ell}$	(P) $T_{lowest} - T_{highest} = 6mg$
(B) $v_0 = \sqrt{g\ell}$	(Q) String will slack for a finite time
(C) $v_0 = 2\sqrt{g\ell}$	(R) bob will oscillate
(D) $v_0 = 3\sqrt{g\ell}$	(S) bob will complete the circle

Q18. The figure below shows a graph of potential energy U(x) versus position x for a particle executing one dimensional motion along the x axis. The total mechanical energy of the system is indicated by the dashed line. The particle is somewhere between points a & d. Slope of tangent at a & d is same.



Column I	**Column II**
(A) Points where magnitude of the force is maximum	(P) (a)
(B) Points where the kinetic energy is maximum	(Q) (b)
(C) Points where the velocity is zero	(R) (c)
(D) Points where the force is zero	(S) (d)

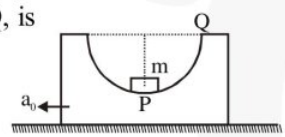
NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q19. A particle of mass 2kg moves on a smooth horizontal plane under the action of a single force $\vec{F} = (3\hat{i} + 4\hat{j})$ newton. Under this force it is displaced from (0,0) to (–1m, 1m). Find the work done by F (in Joule)

Q20. A body constrained to move along the z-axis of a coordinate system is subject to a constant force F given by $F = -\hat{i} + 2\hat{j} + 3\hat{k}$N where $\hat{i}, \hat{j}, \hat{k}$ are unit vectors along the x-, y- and z-axis of the system respectively. What is the work done by this force in moving the body a distance of 4 m along the z-axis ?

Q21. A small block of mass m is lying at rest at point P of a wedge having a smooth semi circular track of radius R. The minimum value of horizontal acceleration a_0 (in m/s^2) of wedge so that mass can just reach the point Q, is



Q22. The potential function for a conservative force is given by U = (x + y). Find the work done by the conservative force in moving a particle from the point A(1, 1) to point B (2, 3).

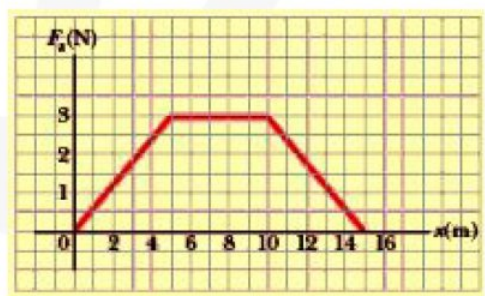
Q23. The potential energy (in joules) function of a particle in a region of space is given as : $U = (2x^2 + 3y^3 + 2z)$ Here x, y and z are in metres. Find the magnitude of x component of force (in newton) acting on the particle at point P (1m, 2m, 3m).

Q24. Power applied to a particle varies with time as $P = (3t^2 - 2t + 1)$ watt, where t is in second. Find the change in its kinetic energy between time t = 2 s and t = 4 s.

Q25. A block is released from rest from top of a rough curved track as shown in figure. It comes to rest at some point on the horizontal part. If its mass is 200 gm, calculate negative of work by friction in joules.

SUBJECTIVE TYPE

Q26. A particle is subject to a force F_x that varies with position as in figure. Find the work done by the force on the body as it moves
(a) from x = 0 to x = 5.00 m,
(b) from x = 5.00 m to x = 10.0 m, and
(c) from x = 10.0 m to x = 15.0 m.
(d) What is the total work done by the force over the distance x = 0 to x = 15.0 m?



Q27. The sign of work done by a force on a body is important to understand. State carefully if the following quantities are positive or negative:
(A) work done by a man in lifting a bucket out of a well by means of a rope tied to the bucket.
(B) work done by gravitational force in the above case,
(C) work done by friction on a body sliding down an inclined plane,
(D) work done by an applied force on a body moving on a rough horizontal plane with uniform velocity,
(E) work done by the resistive force of air on a vibrating pendulum in bringing it to rest.

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. A block of mass m moves up on an inclined plane of angle θ. If μ is the co-efficient of friction between the block and the inclined plane, the work done in moving the block through a distance x along the plane is given by -

(A) mgx (sinθ + μcosθ)

(B) mgx sinθ

(C) mgx (sinθ – μcosθ)

(D) μmgx cosθ

Q2. **Statement 1:** The work done in pushing a block is more than the work done in pulling the block in a rough surface.

Statement 2: In the pushing condition more normal reaction increases the frictional force.

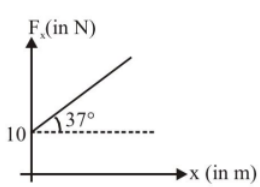
(A) Statement–I is true, Statement–II is true; Statement–II is correct explanation for Statement–I.

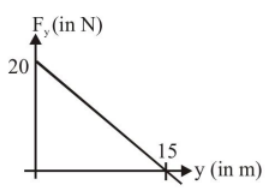
(B) Statement–I is true, Statement–II is true; Statement–II is NOT a correct explanation for Statement–I.

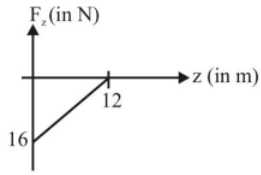
(C) Statement–I is true, Statement–II is false.

(D) Statement–I is false, Statement–II is true.

Q3. The components of a force acting on a particle are varying according to the graphs shown. To reach at point B (8, 20, 0) from point A(0, 5, 12) the particle moves on paths parallel to x-axis then y-axis and then z-axis, then work done by this force is







(A) 192 J (B) 58 J

(C) 250 J (D) 125 J

Q4. A force $\vec{F} = -k(y\hat{i} + x\hat{j})$, where k is a constant, acts on a particle moving in the x-y plane. Starting from the origin, the particle is taken from the origin (0, 0) to the point (a, 0) and then from the point (a, 0) to the point (a, a). The total work done by the force $\vec{F}$ on the particle is :

(A) ka^2 (B) $-ka^2$

(C) $2ka^2$ (D) $-2ka^2$

Q5. When a rubber-band is stretched by a distance x, it exerts a restoring force of magnitude $F = ax + bx^2$ where a and b are constants. The work done in stretching the unstretched rubber-band by L is:-

(A) $\frac{aL^2}{2} + \frac{bL^3}{3}$ (B) $\frac{1}{2}\left(\frac{aL^2}{2} + \frac{bL^3}{3}\right)$

(C) $aL^2 + bL^3$ (D) $\frac{1}{2}(aL^2 + bL^3)$

Q6. A spring of force constant 800 N/m has an extension of 5 cm. The work done in extending it from 5 cm to 15 cm is-

(A) 16 J (B) 8 J (C) 32 J (D) 24 J

Q7. This question has Statement-1 and Statement-2. Of the four choices given after the statements, choose the one that best describes the two statements.

If two springs S_1 and S_2 of force constants k_1 and k_2, respectively, are stretched by the same force, it is found that more work is done on spring S_1 than on spring S_2.

Statement-1: If stretched by the same amount, work done on S_1, will be more than that on S_2

Statement-2 : $k_1 < k_2$.

(A) Statement-1 is true, Statement-2 is true and Statement-2 is not the correct explanation of Statement-1.

(B) Statement-1 is false, Statement-2 is true

(C) Statement-1 is true, Statement-2 is false

(D) Statement-1 is true, Statement-2 is true and Statement-2 is the correct explanation of Statement-1.

Q8. A particle moves on a rough horizontal ground with some initial velocity say v_0. If $\frac{3}{4}$ of its kinetic energy is lost due to friction in time t_0 then coefficient of friction between the particle and the ground is :

(A) $\frac{v_0}{2gt_0}$ (B) $\frac{v_0}{4gt_0}$ (C) $\frac{3v_0}{4gt_0}$ (D) $\frac{v_0}{gt_0}$

Q9. A small sphere starts falling from a very large height and after falling a distance of 100 m it attains the terminal velocity and continues to fall with this velocity. The work done by the atmosphere during the first fall of 100m is :

(A) Greater than the work done for next fall of 100 m

(B) Less than the work done for next fall of 100 m

(C) Equal to 100 mg

(D) Greater than 100 mg

Q10. A car of mass m starts moving so that its velocity varies according to the law $v = a\sqrt{s}$, where a is a constant, and s is the distance covered. The total work performed by all the forces which are acting on the car during the first t seconds after the beginning of motion is :

(A) $ma^4t^2/8$ (B) $ma^2t^4/8$

(C) $ma^4t^2/4$ (D) $ma^2t^4/4$

Q11. A particle moves in a straight line with retardation proportional to its displacement. Its loss of kinetic energy for any displacement x is proportional to-

(A) x^2 (B) e^x

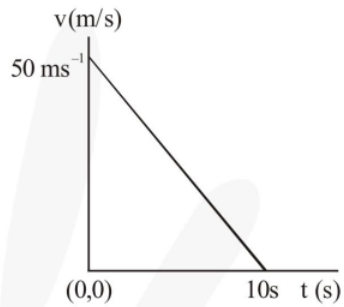
(C) x (D) $\log_e x$

Q12. At time t = 0s particle starts moving along the x-axis. If its kinetic energy increases uniformly with time 't', the net force acting on it must be proportional to :-

(A) $\sqrt{t}$ (B) constant

(C) t (D) $\frac{1}{\sqrt{t}}$

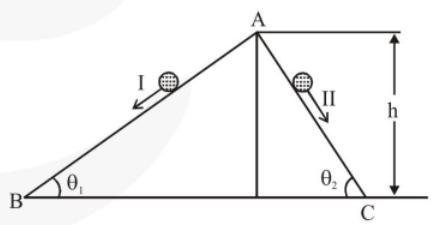
Q13. Velocity-time graph for a body of mass 10 kg is shown in figure. Work-done on the body in first two seconds of the motion is:-



(A) – 9300 J (B) – 12000 J

(C) 12000 J (D) – 4500 J

Q14. Two inclined frictionless tracks, one gradual and the other steep meet at A from where two stones are allowed to slide down from rest, one on each track as shown in figure. Which of the following statement is correct?



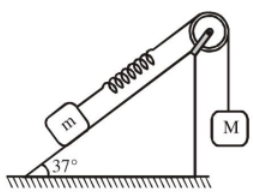
(A) Both the stones reach the bottom at the same time but not with the same speed.

(B) Both the stones reach the bottom with the same speed and stone I reaches the bottom earlier than stone II.

(C) Both the stones reach the bottom with the same speed and stone II reaches the bottom earlier than stone I.

(D) Both the stones reach the bottom at different times and with different speeds.

Q15. A block of mass m is attached with a massless spring of force constant k. The block is placed over a rough inclined surface for which the coefficient of friction is $\mu = \frac{3}{4}$. System is released from rest when the spring was unstretched. The minimum value of M required to move the block up the plane is : (Neglect mass of string and pulley and friction in pulley)



(A) $\frac{3}{5}$ m (B) $\frac{4}{5}$ m

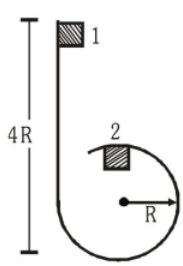
(C) 2 m (D) $\frac{3}{2}$ m

Q16. A simple pendulum has a string of length ℓ and bob of mass m. When the bob is at its lowest position, it is given the minimum horizontal speed necessary for it to move in a circular path about the point of suspension. The tension in the string at the lowest position of the bob is :

(A) 3mg (B) 4mg

(C) 5mg (D) 6mg

Q17. A cube of mass M starts at rest from point 1 at a height 4R, where R is the radius of the circular track. The cube slides down the frictionless track and around the loop. The force which the track exerts on the cube at point 2 is :



(A) 3 mg

(B) mg

(C) 2 mg

(D) cube will not reach the point 2.

Q18. A 2 kg block slides on a horizontal floor with a speed of 4 m/s. It strikes an uncompressed spring, and compresses it till the block is motionless. The kinetic friction force is 15 N and spring constant is 10, 000 N/m. The spring compresses by :-

(A) 5.5 cm (B) 2.5 cm

(C) 11.0 cm (D) 8.5 cm

Q19. **Statement 1 :** One end of ideal massless spring is connected to fixed vertical wall and other end to a block of mass m initially at rest on smooth horizontal surface. The spring is initially in natural length. Now a horizontal force F acts on block away from the wall. Then the maximum extension in spring is equal to maximum compression in spring.

Statement 2 : To compress or to expand an ideal unstretched spring by equal amount, same work is to be done on spring.

(A) Statement–I is true, Statement–II is true; Statement–II is correct explanation for Statement–I.

(B) Statement–I is true, Statement–II is true; Statement–II is NOT a correct explanation for statement–I

(C) Statement–I is true, Statement–II is false

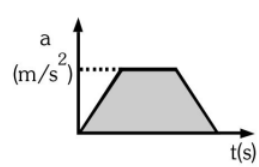
(D) Statement–I is false, Statement–II is true

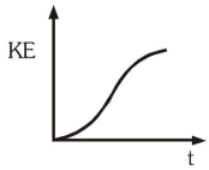
Q20. A mass of M kg is suspended by a weightless string. The horizontal force that is required to displace it until the string makes an angle of 45° with the initial vertical direction is-

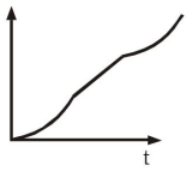
(A) $Mg(\sqrt{2}+1)$ (B) $Mg\sqrt{2}$

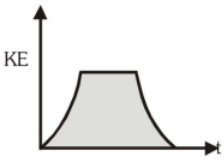
(C) $\frac{Mg}{\sqrt{2}}$ (D) $Mg(\sqrt{2}-1)$

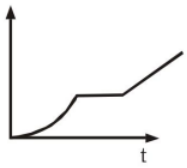
Q21. Acceleration versus time graph of a particle moving in a straight line is as shown in adjoining figure. If initially particle was at rest then corresponding kinetic energy versus time graph will be :



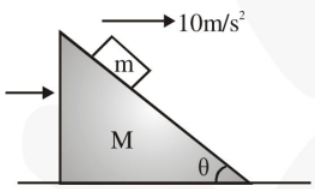
(A) 

(B) 

(C) 

(D) 

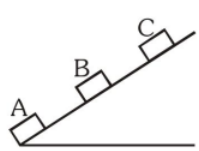
Q22. In the figure shown all the surfaces are frictionless, and mass of the block, m = 1 kg. The block and wedge are held initially at rest. Now wedge is given a horizontal acceleration of 10 m/s^2 by applying a force on the wedge, so that the block does not slip on the wedge. Then work done by the normal force in ground frame on the block in $\sqrt{3}$ seconds is :



(A) 30J (B) 60 J

(C) 150 J (D) 100 $\sqrt{3}$ J

Q23. A block has an initial kinetic energy of 128 J. It slides up from point A at the bottom of the inclined plane with uniform deceleration. When it passes point B, its kinetic energy is reduced by 80 J, and its mechanical energy is reduced by 35 J. Calculate the work done against friction when the block moves from A to the highest point C on the inclined plane.



(A) 42 J (B) 48 J

(C) 56 J (D) 72 J

Q24. A weight is hung freely from the end of a spring. A boy then slowly pushes the weight upwards until the spring becomes slack. The gain in gravitational potential energy of the weight during this process is equal to :

(A) The work done by the boy against the gravitational force acting on the weight.

(B) The loss of the stored energy by the spring minus the work done by the tension in the spring.

(C) The work done on the weight by the boy plus the stored energy lost by the spring.

(D) The work done on the weight by the boy minus the workdone by the tension in the spring plus the stored energy lost by the spring.

Q25. An object of mass m slides down a hill of height h of arbitrary shape and after travelling a certain horizontal path stops because of friction. The total vertical height decended is h. The friction coefficient is different for different segments for the entire path but is independent of the velocity and direction of motion. The work that a tangential force must perform to return the object to its initial position along the same path is :

(A) mgh (B) 2mgh

(C) 4mgh (D) –mgh

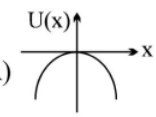
Q26. A particle is moved from (0, 0) to (a, a) under a force $\vec{F} = (3\hat{i} + 4\hat{j})$ from two paths. Path 1 is OP and path 2 is OQP. Let W_1 and W_2 be the work done by this force in these two paths. Then :

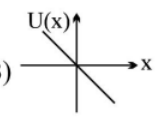
(A) $W_1 = W_2$ (B) $W_1 = 2W_2$

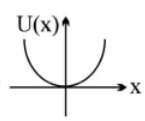
(C) $W_2 = 2W_1$ (D) $W_2 = 4W_1$

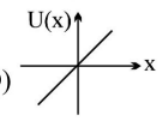
Q27. A particle is placed at the origin and a force F = kx is acting on it (where k is a positive constant). If U(0) = 0, the graph of U(x) versus x will be

(where U is the potential energy function)

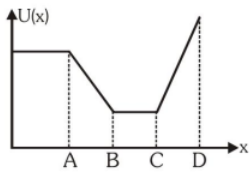
(A) 

(B) 

(C) 

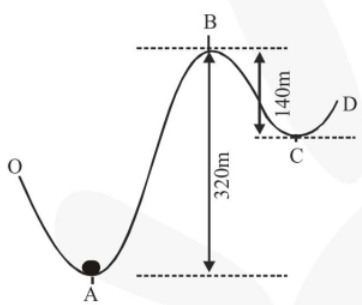
(D) 

Q28. As a particle moves along the x–axis it is acted upon by a conservative force. The potential energy is shown below as a function of the coordinate x of the particle. Rank the labelled regions according to the magnitude of the force, least to greatest.



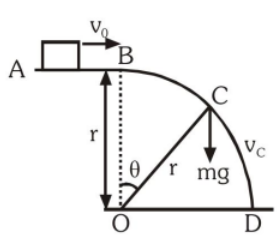
(A) AB, BC, CD (B) AB, CD, BC
(C) BC, CD, AB (D) BC, AB, CD

Q29. Track OABCD (as shown is figure) is smooth and fixed in vertical plane. What minimum speed has to be given to a particle lying at point A, so that it can reach point C?



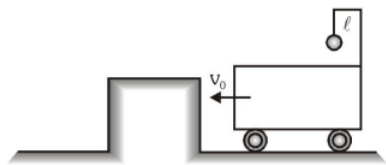
(A) 60 m/s (B) 100 m/s
(C) 70 m/s (D) 80 m/s

Q30. A small block slides with velocity $0.5\sqrt{gr}$ on the horizontal frictionless surface as shown in the figure. The block leaves the surface at point C. The angle θ in the figure is :



(A) $\cos^{-1}\frac{4}{9}$ (B) $\cos^{-1}\frac{3}{4}$
(C) $\cos^{-1}\frac{1}{2}$ (D) $\cos^{-1}\frac{4}{5}$

Q31. A bob is suspended from a crane by a cable of length $\ell = 5$ m. The crane and load are moving at a constant speed v_0. The crane is stopped by a bumper and the bob on the cable swings out an angle of 60°. The initial speed v_0 is– ($g = 9.8$ m/s^2)

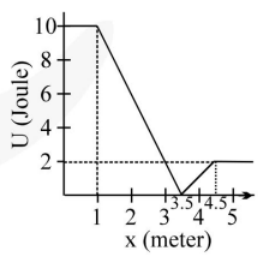


(A) 10 m/s (B) 7 m/s
(C) 4 m/s (D) 2 m/s

Q32. The potential energy of a 1 kg particle free to move along the x-axis is given by $U(x) = \left(\frac{x^4}{4} - \frac{x^2}{2}\right)$J. The total mechanical energy of the particle is 2 J. Then, the maximum speed (in m/s) is-

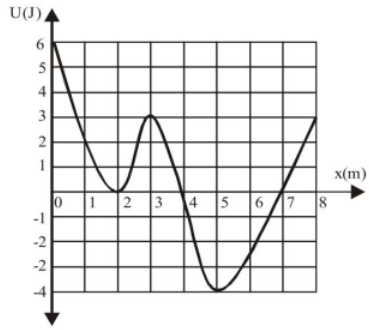
(A) $3/\sqrt{2}$ (B) $\sqrt{2}$
(C) $1/\sqrt{2}$ (D) 2

Q33. A body with mass 2 kg moves in one direction in the presence of a force which is described by the potential energy graph. If the body is released from rest at x = 2m, then its speed when it crosses x = 5 m is



(A) zero (B) 1 ms^{-1}
(C) 2 ms^{-1} (D) 3 ms^{-1}

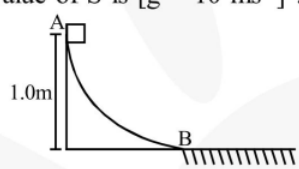
Q34. Potential energy curve U of a particle as function of the position of a particle is shown. The particle has total mechanical energy E of 3.0 joules.



(A) It can never be present at x= 0 m.
(B) It can never be present at x=5 m
(C) At x=2 its kinetic energy is 0 J
(D) At x =1 its kinetic energy 3 J

Q35. A block weighing 10 N travels down a smooth curved track AB joined to a rough horizontal surface (see figure). The rough surface has a friction coefficient of 0.20 with the block. If the block starts slipping on the track from a point 1.0 m above the horizontal surface, then it would move a distance S on the rough surface. The value of S is [g = 10 ms^{-2}] :-

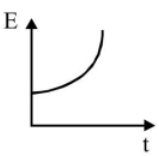
(A) 1m
(B) 2m
(C) 3m
(D) 5m

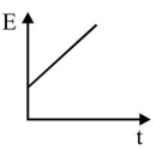


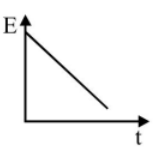
Q36. An ideal spring with spring constant K is hung from the ceiling and a block of mass M is attached to its lower end. The mass is released with the spring initially unstretched. The maximum extension in the spring is :

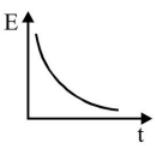
(A) $\frac{4Mg}{K}$ (B) $\frac{2Mg}{K}$ (C) $\frac{Mg}{K}$ (D) $\frac{Mg}{2K}$

Q37. A particle is dropped from a height h. A constant horizontal velocity is given to the particle. Taking g to be constant every where, kinetic energy E of the particle w.r.t. time t is correctly shown in :-

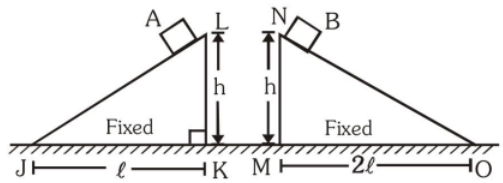
(A) 

(B) 

(C) 

(D) 

Q38. Two identical blocks A and B are placed on two inclined planes as shown in diagram. Neglect air resistance and other friction. Choose the correct statement :



Statement I: Kinetic energy of 'A' on sliding to J will be greater than the kinetic energy of B on falling to M.

Statement II: Acceleration of 'A' will be greater than acceleration of 'B' when both are released to slide on inclined plane.

Statement III : Work done by external agent to move block slowly from position B to O is negative

(A) statement I is true
(B) statement II is true
(C) statement I and III are true
(D) statement II and III are true

Q39. **Statement 1:** A particle is rotated in a vertical circle with the help of a string. Power produced by tension in the string on the particle is zero.

Statement 2 : Tension is always perpendicular to instantaneous velocity and Power = $\vec{F}.\vec{V}$.

(A) Statement–I is true, Statement–II is true; Statement–II is correct explanation for Statement–I.
(B) Statement–I is true, Statement–II is true; Statement–II is NOT a correct explanation for statement–I
(C) Statement–I is true, Statement–II is false
(D) Statement–I is false, Statement–II is true

Q40. A body is moved along a straight line by a machine delivering constant power. The distance moved by the body in time t is proportional to :

(A) $t^{1/2}$ (B) $t^{3/4}$
(C) $t^{3/2}$ (D) t^2

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Which of the following statements is TRUE for a system comprising of two bodies in contact exerting frictional force on each other:

(A) total work done by static friction on whole system is always zero.

(B) work done by static friction on a body is always zero

(C) work done by kinetic friction on a body is always negative

(D) total work done by internal kinetic friction on whole system is always negative

Q2. The kinetic energy of a particle continuously increase with time. Then

(A) the magnitude of its linear momentum is increasing continuously.

(B) its height above the ground must continuously decrease.

(C) the work done by all forces acting on the particle must be positive.

(D) the resultant force on the particle must be parallel to the velocity at all times.

Q3. A simple pendulum of length L and mass (bob) M is oscillating in a plane about a vertical line between angular limits $-\phi$ and ϕ. For an angular displacement θ, $[|\theta|<\phi]$ the tension in the string and velocity of the bob are T and v respectively. The following relations hold good under the above conditions.

(A) $T\cos\theta = Mg$

(B) $T - Mg\cos\theta = \frac{Mv^2}{L}$

(C) Tangential acceleration = $g\sin\theta$

(D) $T = Mg\cos\theta$

Q4. A particle is given a velocity at the bottom most position in a smooth spherical shell of radius 2m. It just complete a vertical circular motion. Then

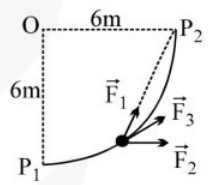
(A) Acceleration of particle when the velocity of the particle is in vertically upward direction is $g\sqrt{5}$

(B) Acceleration of particle when the velocity of the particle is in vertically downward direction is $g\sqrt{5}$

(C) Acceleration of the particle at the top most point of path is g

(D) Acceleration of the particle at the bottom most point is 5 g

Q5. A smooth track in the form of a quarter circle of radius 6 m lies in the vertical plane. A particle moves from P_1 to P_2 under the action of forces $\vec{F}_1$, $\vec{F}_2$ and $\vec{F}_3$. Force $\vec{F}_1$ is always toward P_2 and is always 20N in magnitude. Force $\vec{F}_2$ always acts horizontally and is always 30 N in magnitude. Force $\vec{F}_3$ always acts tangentially to the track and is of magnitude 15 N. Select the correct alternative(s)



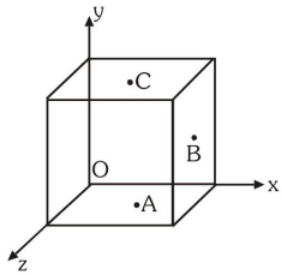
(A) work done by $\vec{F}_1$ is 120 J

(B) work done by $\vec{F}_2$ is 180 J

(C) work done by $\vec{F}_3$ is 45π

(D) $\vec{F}_1$ is conservative in nature

Q6. A particle is shifted from A to B and then from B to C where A, B and C are the mid-points of the corresponding faces of a cube of side 2m. If a force $\vec{F} = \left(3\hat{i} + 4\hat{j} - 5\hat{k}\right)$ N is continuously acting on the particle, then select correct alternative :-



(A) work done from A to B is 7 J

(B) work done from B to C is 1 J

(C) work done A to C is 8 J

(D) $\vec{F}$ is a conservative force

Q7. The potential energy of a particle moving along x–axis is given by U = 40 + 20 sin (4πx) where U is in J and x is in metre. Under the action of conservative force

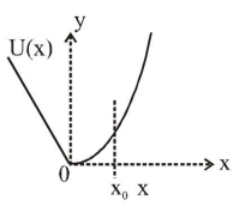
(A) If total mechanical energy is 60 J, then at $x = \frac{9}{8}$ m, particle is in equilibrium.

(B) If total mechanical energy is 60 J, then at $x = \frac{9}{8}$ m, particle is not in equilibrium.

(C) If total mechanical energy is 60 J, then at $x = \frac{5}{8}$m, particle's kinetic energy is minimum.

(D) If total mechanical energy is 60 J, then at $x = \frac{5}{8}$m, particle's kinetic energy is maximum.

Q8. A particle is released from rest at the position $x = x_0$. The potential energy graph of the particle is shown below.



$$U(x) = \begin{cases} -ax\ ;\ x < 0 \\ bx^2\ ;\ x > 0 \end{cases}$$

Which of the following statements is/are correct ?

(A) The subsequent motion is periodic.

(B) The subsequent motion is oscillatory

(C) The acceleration is a continuous function of time

(D) The subsequent motion is simple harmonic

Q9. A particle of mass *m* is at rest in a train moving with constant velocity with respect to ground. Now the particle is accelerated by a constant force F_0 acting along the direction of motion of train for time t_0. A girl in the train and a boy on the ground measure the work done by this force. Which of the following are **INCORRECT**?

(A) Both will measure the same work

(B) Boy will measure higher value than the girl

(C) Girl will measure higher value than the boy

(D) Data are insufficient for the measurement of work done by the force F_0

Q10. A particle of mass 2 kg is projected with an initial speed u = 10 m/sec at an angle θ = 30° with the horizontal

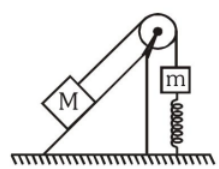
(A) Total work done on the particle during the first half of the total time of flight of the particle is (–25) J.

(B) Total work done on the particle during the total time of flight of the particle is 0J.

(C) Average power delivered to the particle during the first half of the flight is (–50) watt.

(D) The radius of curvature of the trajectory of the particle at the highest point of the projectile is 7.5m.

Q11. A large block of mass M on a smooth inclined plane is connected via a string to a small block m, which is attached to relaxed spring of force constant k with its other end attached to the ground (see diagram). Which of the following forces do negative work as the large block slides down the incline.



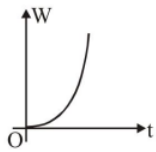
(A) The tension force on m.

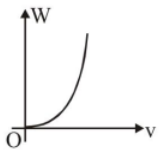
(B) The gravitational force on m.

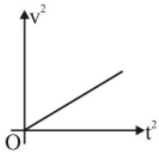
(C) The spring force on m.

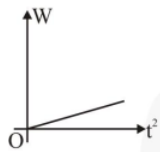
(D) The tension force on M.

Q12. A particle initially at rest on a smooth horizontal surface, is acted on by a constant horizontal force at time t =0. Then if W = work done, t = time and v = speed of the particle, the nearly correct graph(s) is/are :-

(A) 

(B) 

(C) 

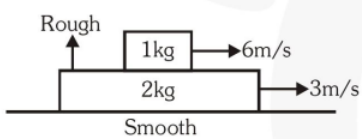
(D) 

PARAGRAPH TYPE

*This section contains **PARAGRAPHS**. Based on each paragraph, there are questions. Each question has FOUR options. **ONLY ONE** of these four options corresponds to the correct answer. For each question, choose the option corresponding to the correct answer.*

Paragraph for Question No. 13 & 14

In the figure shown upper block is given a velocity of 6 m/s and lower block 3 m/s. When relative motion between them is stopped.



Q13. (A) Work done by friction on upper block is negative

(B) Work done by friction on both the blocks is positive

(C) Work done by friction on lower block is negative

(D) Work done by friction on both the blocks is negative

Q14. (A) Work done by friction on upper block is – 10 J

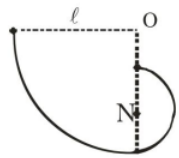
(B) Work done by friction on lower block is + 10 J

(C) Net work done by friction is zero

(D) All of the above

Paragraph for Question No. 15 to 17

The bob of simple pendulum of length ℓ is released from a point in the same horizontal line as the point of suspension (O) and at a distance ℓ from it.



Q15. The velocity of the bob at the lowest point of the string will be

(A) $v = \sqrt{2g\ell}$ (B) $v = \sqrt{g\ell}$

(C) $v = \sqrt{3g\ell}$ (D) $v = 2\sqrt{g\ell}$

Q16. If the string is catched by a nail located vertically below the point of suspension and the bob just swings around a complete circle around the nail, then the distance of the nail from point of suspension.

(A) $(2/5)\ell$ (B) $(2/3)\ell$

(C) $(3/5)\ell$ (D) $(1/3)\ell$

Q17. If the string of the pendulum is made of rubber then how much will it be stretched on reaching the bob at the lowest point.

(A) 2mg/k (B) 3mg/k

(C) 5 mg/k (D) mg/k

Paragraph for Question No. 18 & 19

A pendulum is suspended vertically from a point at rest. A force F in horizontal direction starts acting on it of constant magnitude $\frac{3}{4}Mg$ as shown. Pendulum bob is of mass m and string of length ℓ and acceleration due to gravity g.

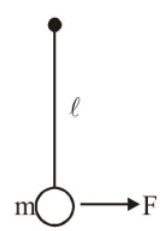
Q18. The angle made by string with vertical, when the speed of the bob is maximum, is :-

(A) 37°

(B) $\sin^{-1}\left(\frac{3}{5}\right)$

(C) $\cos^{-1}\left(\frac{4}{5}\right)$

(D) 53°



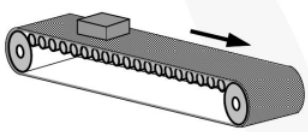
Q19. The minimum horizontal velocity that must be given to the bob at the initial position shown, such that the bob completes the circle is :-

(A) $\sqrt{5g\ell}$ (B) $\sqrt{\frac{25}{4}g\ell}$

(C) $\sqrt{\frac{24}{5}g\ell}$ (D) $\sqrt{\frac{23}{4}g\ell}$

Paragraph for Question 20 & 21

An object of mass M is gently placed on a horizontal conveyor belt, which is moving with uniform velocity v_o as shown in the figure. The coefficient of static friction is μ_s, the coefficient of kinetic friction is μ_k, and the acceleration of gravity is g. Initially the object slips for a while but finally moves without slipping together with the belt.



Q20. How far the conveyor belt moves while the object is slipping?

(A) $\frac{v_o^2}{\mu_k g}$ (B) $\frac{v_o^2}{2\mu_k g}$

(C) $\frac{v_o^2}{\mu_s g}$ (D) $\frac{v_o^2}{2\mu_s g}$

Q21. Work done on the object by friction force relative to the reference frame moving with the conveyer belt is

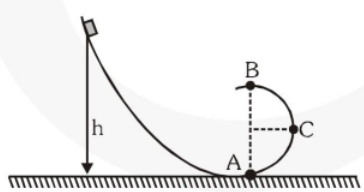
(A) $\frac{1}{2}Mv_o^2$ (B) $-\frac{1}{2}Mv_o^2$

(C) Mv_o^2 (D) zero

MATCH THE COLUMN TYPE

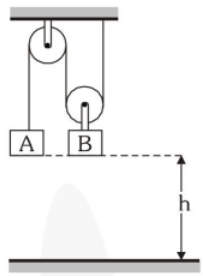
*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

Q22. A block of mass m is released from top of a smooth track as shown in the figure. The end part of the track is a circle in vertical plane of radius R. N is normal reaction of the track at any point of the track. Match the entries of column I with entries of column–II.



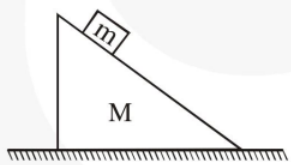
Column I	**Column II**
(A) $h = \frac{5}{2}R$	(P) Net force on the block at C is mg
(B) $h = \frac{9}{2}R$	(Q) $N_A - N_B = 6$ mg
(C) $h = R$	(R) Block leaves contact before B
(D) $h = 2R$	(S) Block will keep contact with the track is region between A & B.
	(T) $N_C > mg$

Q23. In the figure shown are two blocks A and B of same mass connected with pulley and string to each other. Initially both of them are at a height of h = 0.5 m from ground. After they are released they move in either direction and one of them strike the ground. For, the interval from releasing to when one of them strike, some physical quantities are in column I and their modulus values in SI units are in column II.



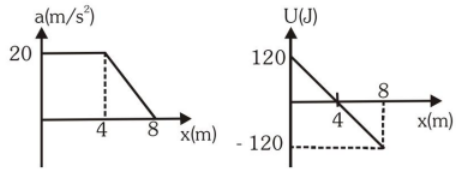
Column I	**Column II**
(A) Velocity of A immediately before any one of them strike ground.	(P) 1
(B) Velocity of B immediately before any one of them strike ground.	(Q) 2
(C) Ratio of work done by gravity on A to workdone by gravity on B.	(R) 3
(D) Acceleration of block A before any one of them strike ground.	(S) 4
	(T) 5

Q24. A block of mass m lies on wedge of mass M. The wedge in turn lies on smooth horizontal surface. Friction is absent everywhere. The wedge block system is released from rest. All situation given in column–I are to be estimated in duration the block undergoes a vertical displacement 'h' starting from rest (assume the block to be still on the wedge, g is acceleration due to gravity).



Column I	**Column II**
(A) Work done by normal reaction acting on the block is	(P) Positive
(B) Work done by normal reaction (exerted by block) acting on wedge is	(Q) Negative
(C) The sum of work done by normal reaction on block and work done by normal reaction (exerted by block) on wedge is	(R) Zero
(D) Net work done by all forces on block is	(S) Less than mgh in magnitude

Q25. Acceleration 'a' versus x and potential energy 'U' versus x graph of a particle moving along x–axis under some conservative and other external forces is as shown in figure. Mass of the particle is 1kg and velocity at x = 0 is 4 m/s. U-x graph is for conservative forces.At x = 8m :-

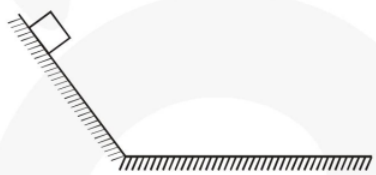


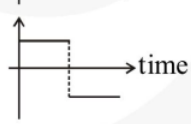
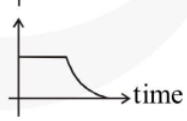
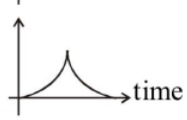
Column I	**Column II**
(A) Kinetic energy	(p) 120J
(B) Work done by conservative forces	(q) 240 J
(C) Total work done	(r) 128 J
(D) Work done by external forces	(s) 112 J
	(t) –120 J

MATCHING LIST TYPE

*Each question has TWO (02) **matching lists: LIST I and LIST II**. FOUR options are given representing matching of elements from LIST I and LIST II. ONLY ONE of these four options corresponds to a correct matching. For each question, choose the option corresponding to the correct matching.*

Q26. A block slides down a smooth inclined plane & then moves on to a rough horizontal surface. List-I gives quantities related to block. List-II gives corresponding graphs of physical quantities versus time :-



List-I	**List-II**
(P) Velocity	(1)
(Q) Acceleration	(2) 
(R) Mechanical energy	(3) 
(S) Kinetic energy	(4) 

Code :

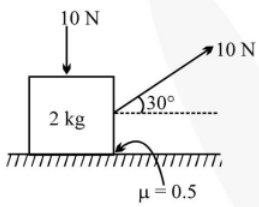
	P	**Q**	**R**	**S**
(A)	1	2	3	4
(B)	4	3	2	1
(C)	2	3	1	4
(D)	3	2	4	1

NUMERICAL TYPE

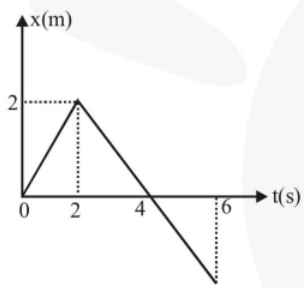
*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q27. A point mass of 0.5 kg is moving along x-axis as $x = t^2 + 2t$, where, x is in meters and t is in seconds. Find the work done (in J) by all the forces acting on the body during the time interval [0, 2s].

Q28. A body of mass 2 kg is kept on a rough horizontal surface as shown in the figure. Find the work done by frictional force in the time interval t = 0 to t = 5 sec.



Q29. Position-time graph of a particle of mass 2 kg is shown in figure. Total work done on the particle from t = 0 to t = 4s is -

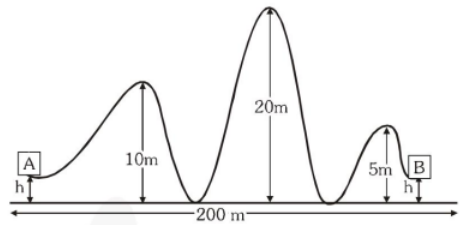


Q30. A force given by the relation F = 8 (N/s)t acts on a body of mass 2 kg initially at rest on a smooth surface where t is in seconds. Find the work done by this force on the body during first 2 seconds of its motion. Assume direction of force remain constant and body moves in the direction of force.

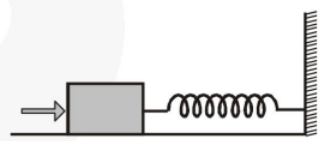
Q31. A spring, which is initially in its unstretched condition, is first stretched by a length x and then again by a further length x. The work done in the first case is W_1 and in the second case is W_2. Find $\frac{W_2}{W_1}$.

Q32. A point object of mass 2 kg is moved from point A to point B very slowly on a curved path by applying a tangential force on a curved path as shown in figure. Then find the work done by external force in moving the body. Given that $\mu_s = 0.3$, $\mu_k = 0.1$.

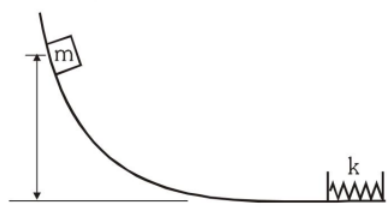
[$g = 10\ m/s^2$]



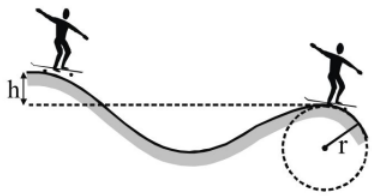
Q33. A block of mass 0.18 kg is attached to a spring of force-constant 2 N/m. The coefficient of friction between the block and the floor is 0.1. Initially the block is at rest and the spring is un-stretched. An impulse is given to the block as shown in the figure. The block slides a distance of 0.06 m and comes to rest for the first time. The initial velocity of the block in m/s is V= N/10. Then N is -



Q34. A mass m slides from rest at height h down a smooth curved surface which becomes horizontal at zero height (see figure). A spring is fixed horizontally on the level part of the surface. The spring constant is k N/ m. When the mass encounters the spring it compresses it by an amount x = h/10. If m = 1 kg, h = 5m then find k /100.



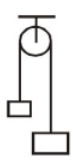
Q35. A skier starts from rest at the top of a hill. The skier coasts down the hill and up a second hill, as the drawing illustrates. The crest of the second hill is circular, with a radius of r = 36 m. Neglect friction and air resistance. What must be the height h (in m) of the first hill so that the skier just loses contact with the snow at the crest of the second hill?



Q36. An object of mass 4 kg falls from rest through a vertical distance of 10 m and reaches ground with a speed of 14 m/s. How much work is done against air friction in joules? [g = 10 m/s^2]

SUBJECTIVE TYPE

Q37. A light inextensible string that goes over a smooth fixed pulley as shown in the figure connects two blocks of masses 0.36 kg and 0.72 kg. Taking g = 10 m/s^2, find the work done (**in joules**) by the string on the block of mass 0.36 kg during the first second after the system is released from rest.



Q38. A body of mass 2 kg initially at rest moves under the action of an applied horizontal force of 7 N on a table with coefficient of kinetic friction = 0.1. Compute the

(A) work done by the applied force in 10 s,

(B) work done by friction in 10 s,

(C) work done by the net force on the body in 10 s,

(D) change in kinetic energy of the body in 10 s, and interpret your results.

Q39. A 4 kg particle moves along the X-axis. It's position x varies with time according to x(t) = t + 2t^3, where x is in m and t is in seconds. Compute:

(i) The kinetic energy at time t.

(ii) The force acting on the particle at time t.

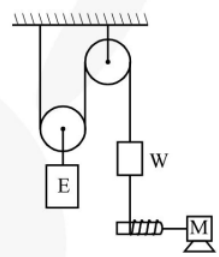
(iii) The power delivered to the particle at time t.

(iv) The work done on the particle from t = 0 to t = 2 seconds.

Q40. The elevator E has a mass of 3000 kg when fully loaded and is connected as shown to a counterweight W of mass 1000 kg. Determine the power in kilowatts delivered by the motor :

(a) when the elevator is moving down at a constant speed of 3 m/s,

(b) when it has an upward velocity of 3 m/s and a deceleration of 0.5 m/s^2.



Q41. A particle of mass m is hanging with the help of an elastic string of unstretched length a and force constant $\frac{mg}{a}$. The other end is fixed to a peg on vertical wall. String is given an additional extension of 2a in vertical downward direction by pulling the mass and released from rest. Find the maximum height reached by it during its subsequent motion above point of release.

(Neglect interaction with peg if any)

Answer Key

Ex-1									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
C	C	B	D	C	C	C	D	B	B
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
B	C	B	A	A	C	B	B	B	A
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**		
C	B	A	A	D	B	B	A		

Ex- 1A

1. B **2.** A,B,C **3.** A,C,D **4.** A,C **5.** A, D

6. A,D **7.** C **8.** D **9.** A **10.** B

11. D **12.** B **13.** B **14.** D

15. (A) PQR (B) PQR (C) R (D) RS

16. (A)–T, (B) –P, (C)–S, (D)–Q **17.** (A)–P,S (B) –R, (C)–Q, (D)–P,S

18. (A)-P, S, (B) -Q, (C)-P, S, (D)-Q, R **19.** 1 **20.** 12 J

21. 10 **22.** –3 **23.** 4 **24.** 46 J **25.** 4

26. (a) 7.5 J (b) 15 J (c) 7.5 J (d) 30 J

27. (A) +ve (B) –ve (C) –ve (D) +ve (E) –ve

Ex-2									
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**
A	A	C	B	A	B	B	A	B	A
11	**12**	**13**	**14**	**15**	**16**	**17**	**18**	**19**	**20**
A	D	D	**C**	**A**	**D**	**A**	A	D	D
21	**22**	**23**	**24**	**25**	**26**	**27**	**28**	**29**	**30**
A	C	C	**C**	**B**	A	A	D	D	B
31	**32**	**33**	**34**	**35**	**36**	**37**	**38**	**39**	**40**
B	A	C	A	D	B	A	D	**A**	C

Ex- 2A

1. A, D	2. A,C	3. B,C	4. C,D	5. B,C,D
6. A,B,C,D	7. A,C	8. A,B	9. A,C	10. A,B,C,D
11. B,C,D	12. A,B,C,D	13. A	14. A	15. A
16. C	17. B	18. A,B,C	19. D	20. A

21. B

22. (A) → (Q,S,T); (B) → (Q,S,T); (C) → (P); (D) → (R,T)

23. (A)→(Q); (B)→(P); (C)→(Q); (D)→(S)

24. (A) Q,S; (B) P,S; (C) R,S; (D) P,S

25. (A)–r, (B)–q, (C)–p, (D)–t

26. A	**27.** 8J	**28.** zero	**29.** 0	**30.** 64 J
31. 3	**32.** 400 J	**33.** 4	**34.** 4	**35.** 18m
36. 8	**37.** 8J			

38. (A) 875 J; (B) –250 J; (C) 625 J ; (D) 625 J

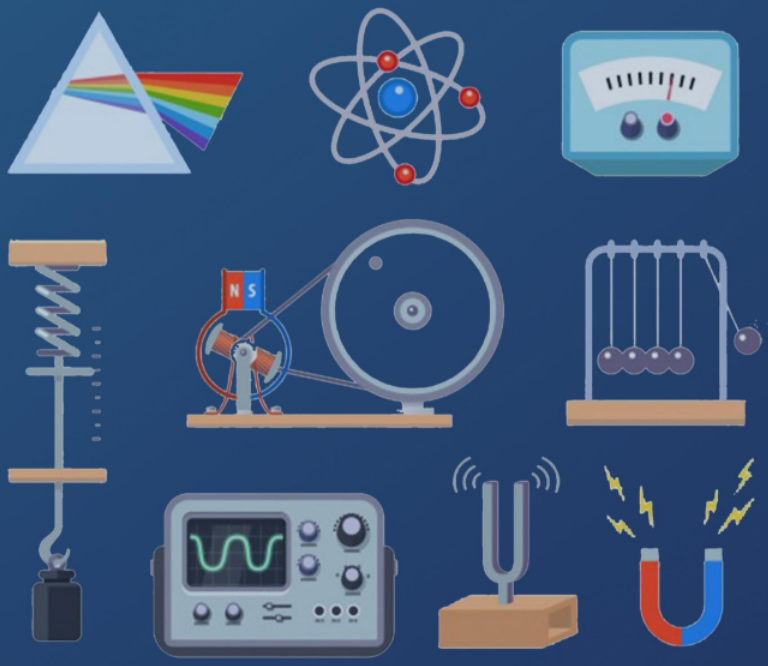
39. (i) $2 + 24t^2 + 72t^4$ J, (ii) 48 t N, (iii) $48t + 288t^3$ W, (iv) 1248 J

40. (a) –30 kW, 19.5 kW

41. $\frac{9a}{2}$

PHYSICS

X-ray



SHEET

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7.	Answer Key	Page - 4

Note

Detailed solutions are available on the eSaral App.

Module Description

For mastering the concepts only learning is not sufficient. We have to practice and apply those concepts in problem solving. This sheet does just that. It contains a collection of problems segregated in the following exercises to help you master the concepts in a systematic and organized way.

"Practice makes a man perfect"

1. Concept builder – 1 & 1A

As soon as you have finished learning the concept do the problems from these exercises first. These exercises contains easy level questions to help you build your concepts.

1 ⟶ Contains Single Correct Type questions

1A ⟶ Contains pattern based questions incorporating the latest JEE Advanced based patterns like more than one correct, matching list, match the column, etc.

2. Brain Booster – 2 & 2A

Now that you have built your concepts it's time to master them by solving Brain Boosting problems. Don't hurry through these problems. Take time to solve & learn from them. These exercises contains Medium & Tough level problems.

Do questions from 2 & 2A after attempting 1 & 1A

2 ⟶ Single Correct Type questions.

2A ⟶ Pattern Based questions.

3. Simulator – JM & JA

Contains questions from previous year JEE Mains & JEE Advanced questions in exercise JM & exercise JA respectively. Get the real taste & feel of the type of questions being asked in JEE. It's a great tool for simulating your mind with JEE problems.

These exercises are not included in the module but are provided separately.

JM ⟶ JEE Mains previous years topic wise questions.

JA ⟶ JEE Advance previous years topic wise questions.

Home Work Index

Problem solving is an integral part of learning.

Find questions to solve after each video in the homework Index. Make sure that you attempt all the problems (in Ex 1 to 2A) after learning a topic from the videos. For example if you have finished topic 8, first attempt all the problems listed in the index corresponding to topic 8 before proceeding to the video of topic 9.

Sr.No.	Topic Name	Ex-1	Ex-1A	Ex-2	Ex-2A
1	Coolidge Tube	1,2			5
2	Continuous X-Rays	3,4			1
3	Characteristic X-Rays	5-7	1,2	1	6
4	Moseley's Law			2-4	2,7,8
5	Bragg's Law				3,4

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Coolidge Tube

Q1. Which of the following are the characteristics required for the target to produce X–rays

Option :	(A)	(B)	(C)	(D)
Atomic number	Low	High	Low	High
Melting point	High	High	Low	Low

Q2. In a Coolidge tube experiment, the minimum wavelength of the continuous X–ray spectrum is equal to 66.3 pm, then

(A) electrons accelerate through a potential difference of 12.75 kV in the Coolidge tube

(B) electrons accelerate through a potential difference of 18.75 kV in the Coolidge tube

(C) de–Broglie wavelength of the electrons reaching the anticathode is of the order of 10 μm

(D) de–Brgolie wavelength of the electrons reaching the anticathode is 0.01 Å

Continuous x-rays

Q3. On operating an X–ray tube at 1 kV. X–rays of minimum wavelength 6.22 Å are produced. If the tube is operated at 10 kV, then the minimum wavelength of X–rays produced will be

(A) 0.622 Å (B) 6.22 Å

(C) 3.11 Å (D) 62.2 Å

Q4. In an X-ray tube, electrons striking a target are brought to rest, causing X-rays to be emitted. In a particular X-ray tube, the maximum frequency of the emitted continuum X-ray spectrum is f_o. If the voltage across the tube is doubled, the maximum frequency is

(A) $f_o / 2$ (B) $f_o / \sqrt{2}$

(C) f_o (D) $2f_o$

Characteristic x-rays

Q5. The K_α X–ray emission line of tungsten occurs at $\lambda = 0.021$ nm. The energy difference between K and L levels in this atoms is about :

(A) 0.51 MeV (B) 1.2 MeV

(C) 59 keV (D) 13.6 eV

Q6. The production of characteristic X–rays is due to–

(A) transfer of momentum in collision of electrons with the target atom

(B) transfer of energy in collision of electrons with the target atom

(C) the transition of electrons in heavy target atoms from high to low energy level

(D) none of these

Q7. Characteristic X–rays are not obtained in the spectrum of H–atom because–

(A) hydrogen is a gas

(B) hydrogen is very light

(C) energy difference in energy levels of hydrogen is much less

(D) energy difference in energy levels of hydrogen is much high

Exercise - 1A — Concept Builder

ONE OR MORE THAN ONE CORRECT TYPE

*Each question has FOUR options for correct answer(s). **ONE OR MORE THAN ONE** of these four option(s) is (are) correct option(s). For each question, choose the correct option(s) to answer the question.*

Q1. Which of the following is/are not true for x-rays ?

(A) Wavelength of continuous x-rays does not depend on potential difference

(B) Wavelength of discrete x-rays does not depends on potential difference

(C) Discrete x-rays have energy of the order of MeV

(D) Continuous x-rays have energy of the order of KeV

ASSERTION AND REASON

(A) Statement-1 is true, statement-2 is true and statement-2 is correct explanation for statement-1.

(B) Statement-1 is true, statement-2 is true and statement-2 is NOT the correct explanation for statement-1.

(C) Statement-1 is true, statement-2 is false.

(D) Statement-1 is false, statement-2 is true.

Q2. **Statement–1 :** The frequency of K_α X–radiation is greater than K_β for a given target material.

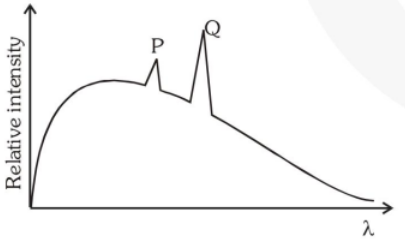
Statement–2 : K_α radiation is produced when an electron from n = 2 jumps into the vacancy in n = 1 orbit; whereas in K_β radiation the transition takes place from n = 3 to n = 1.

Exercise - 2 — Brain Booster

SINGLE CORRECT TYPE

*Each question has FOUR options for correct answer. **ONLY ONE** of these four options is correct option. For each question, choose the correct option to answer the question.*

Q1. In a characteristic X–ray spectra of some atom superimposed on continuous X–ray spectra



(A) P represents K_α line

(B) Q represents K_β line

(C) Q and P represents K_α and K_β lines respectively

(D) Relative positions of K_α and K_β depends on the particular atom

Q2. The wavelength of K_α line for an element of atomic number 43 is λ. Then the wavelength of K_α line for an element of atomic number 29 is :–

(A) (43/29) λ (B) (42/28) λ

(C) (9/4) λ (D) (4/9) λ

Q3. The wavelengths of K_α X–rays of two metals 'A' and 'B' are $\frac{4}{1875R}$ and $\frac{1}{675R}$ respectively, where 'R' is Rydberg constant. The number of elements lying between 'A' and 'B' according to their atomic numbers is :

(A) 3 (B) 6 (C) 5 (D) 4

Q4. The constant 'a' in Mosely's law $\sqrt{\nu} = a(Z-b)$ for K_α X-ray is related to Rydberg constant R as ('c' is the speed of light)

(A) $R = \frac{4a^2}{3c}$ (B) $R = \frac{3c}{4a}$

(C) $R = \frac{3c^2}{4}$ (D) $R = \frac{2c}{a}$

ONE OR MORE THAN ONE CORRECT TYPE

Q1. The potential difference applied to an X–ray tube is increase. As a result, in the emitted radiation

(A) the intensity increases

(B) the minimum wavelength increases

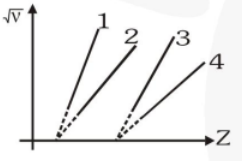
(C) the intensity decreases

(D) the minimum wavelength decreases

MATCH THE COLUMN TYPE

*Following questions contain statements given in two columns, which have to be matched. The statements in **Column-I** are labelled as A, B, C and D while the statements in **Column-II** are labelled as (P), (Q), (R) and (S). Any given statement in **Column-I** can have correct matching with **ONE OR MORE** statement(s) in **Column-II**.*

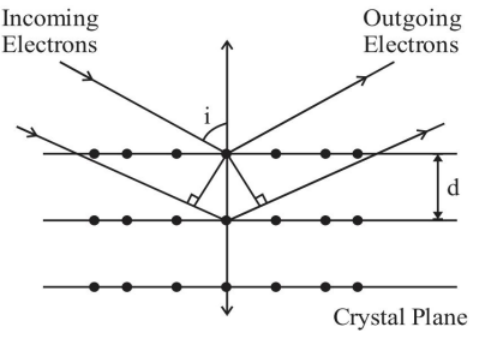
Q2. $\sqrt{\nu}$ versus Z graph for characteristic X–rays is as shown in figure. Match the following :



	Column I	Column II
(A)	Line – 1	(p) L_α
(B)	Line – 2	(q) L_β
(C)	Line – 3	(r) K_α
(D)	Line – 4	(s) K_β

Paragraph for Question No. 3 to 4

Wave property of electrons implies that they will show diffraction effects. Davisson and Germer demonstrated this by diffracting electrons from crystals. The law governing the diffraction from a crystal is obtained by requiring that electron waves reflected from the planes of atoms in a crystal interfere constructively (see figure).



Q3. Electrons accelerated by potential V are diffracted from a crystal.

If d = 1 Å and i = 30°, V should be about

($h = 6.6 \times 10^{-34}$ J-s, $m_e = 9.1 \times 10^{-31}$ kg, $e = 1.6 \times 10^{-19}$ C)

(A) 2000 V (B) 50 V

(C) 500 V (D) 1000 V

Q4. If a strong diffraction peak is observed when electrons are incident at an angle i from the normal to the crystal planes with distance d between them (see figure), de-Broglie wavelength λ_{dB} of electrons can be calculated by the relationship

(n is an integer)

(A) $d \sin i = n\lambda_{dB}$ (B) $2d \cos i = n\lambda_{dB}$

(C) $2d \sin i = n\lambda_{dB}$ (D) $d \cos i = n\lambda_{dB}$

NUMERICAL TYPE

*The answer to each question is a **NUMERICAL VALUE**. For each question, find the correct numerical value (in decimal notation, truncated/ rounded-off to the second decimal place; e.g. 6.25, 7.00, -0.33, -.30, 30.27, -127.30)*

Q5. The K_α X–ray of molybdenum has wavelength 71pm. If the energy of a molybdenum atom with a K electron knocked out is 23·32 keV, What will be the energy of this atom when an L–electron is knocked out?

Q6. If three times of λ_{min} of continuous X–ray spectrum of target metal at 40 kV is same as the wavelength of K_α line of this metal at 30 kV, then determine the atomic number of the target metal .

SUBJECTIVE TYPE

Q7. An X–ray tube, operated at a potential difference of 40 kV, produces heat at the rate of 720 W. Assuming 0.5% of the energy of incident electrons is converted into X–rays, calculate

(i) the number of electron per second striking the target.

(ii) the velocity of the incident electrons

Q8. When X-rays of wavelength 0.5Å pass through 10 mm thick 'Al' sheet then thier intensity is reduced to one sixth. Find the absorption co-efficient for Al.

Answer Key

Ex-1						
1	2	3	4	5	6	7
B	B	A	D	C	C	C

Ex-1A

1. A,C,D **2.** D

Ex-2			
1	2	3	4
C	C	D	A

Ex-2A

1. A,D **2.** (A) s (B) r (C) q (D) p **3.** B **4.** B

5. 5.86 keV **6.** 37

7. (i) 1.1×10^{17} (ii) 1.2×10^{8} m/s **8.** 0.18 mm^{-1}